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Strategic Environmental Research and Development Program

Long-Term Monitoring Program, Fort Benning, GA; Ecosystem Characterization and Monitoring Initiative, Version 2.1

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Final report

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Preface

This report was prepared for the Ecosystem Characterization and Monitoring Initiative (ECMI) sponsored by the Strategic Environmental Research and Development Program (SERDP) Ecosystem Management Project (SEMP). This report was written by Dr. M. Rose Kress, Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC). Project Manager for the ECMI is Dr. David Tazik, EL, ERDC, Vicksburg, MS. Program Manager for the SEMP is Dr. Harold Balbach, and Mr. William Goran is former SEMP Program Manager, Construction Engineering Research Laboratory, ERDC, Champaign, IL.

Many individuals contributed ideas, concepts, and materials to the report. Specific acknowledgement is made to the following: Dave Tazik, Jean O'Neil, David Price, Patrick Deliman, John Hains, and Drew Miller of EL, ERDC; John Brent, Pete Swiderek, and Theresa Davo of Fort Benning, GA; John Hall of The Nature Conservancy; and George Gertner of University of Illinois, Champaign, IL. Graphics and other support were provided by Elizabeth Lord of DynTel.

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1 Introduction

Purpose and Scope

The purpose of this report is to describe the long-term baseline ecosystem monitoring plan developed for Fort Benning, GA, under the Department of Defense (DOD), Strategic Environmental Research and Development Program (SERDP), Ecosystem Management Project (SEMP), Ecosystem Characterization and Monitoring Initiative (ECMI). The report documents the monitoring plan and provides the foundation needed for implementation activities to begin. The scope of this report is limited to the content and design of the Fort Benning, GA, ECMI monitoring plan.

This report provides an executive summary of all components of the ECMI monitoring plan for Fort Benning, GA. It is intended to provide concise summary information on the thematic, spatial, and temporal design elements in sufficient detail for understanding, review, and comment on the overall approach and design. One-page summary sheets providing additional detail about individual monitoring components are included in Appendix A.

Background

DOD policy has established ecosystem management as its approach to management of military lands (DUSD[ES] 8 August 1994 Memorandum to all Services; DOD Instruction 4715.3, Environmental Conservation Program; see also Goodman 1996). The DOD goal for adopting an ecosystem approach to land management is to maintain and improve the sustainability of military lands while supporting the DOD mission. However, gaps in the fundamental knowledge and understanding of ecological processes hinder the ability of DOD to successfully implement comprehensive, ecosystem-based land management practices.

In support of the goal to achieve sustainability of military lands and to begin filling ecological knowledge gaps, the SERDP initiated the SEMP in December 1997. The SEMP has three broad objectives:

- Establish long-term research sites on DOD lands for military-relevant ecosystem research.

- Conduct ecosystem research and monitoring activities relevant to DOD requirements and opportunities.

- Facilitate the integration of results and findings of research into DOD ecosystem management practices.

2 Ecosystem Characterization and Monitoring Initiative

Concept

Within the SEMP, the ECMI was established to design, develop, and demonstrate an ecosystem characterization and monitoring concept appropriate for military installations. The ECMI products must support multiple SEMP objectives and be beneficial to installation land managers. The ECMI baseline monitoring concepts are intended to have broad applicability and may serve as a model for other installations.

The objective of ECMI is to develop a framework to characterize the long-term spatial and temporal dynamics of key ecosystem properties and processes in a way that is jointly beneficial to ecosystem research activities and military land management operations. The monitoring conducted under the ECMI is expected to produce a multipurpose, integrated, baseline ecological information base. This ECMI information base will:

- Support SEMP ecological research related to sustainable management of DOD lands.

- Contribute baseline level data to the integrated monitoring plan of the host site.

- Establish a long-term ecological data set at the host site that will, over time, allow the assessment of relationships between land use and management and ecosystem sustainability.

- Be compatible with monitoring data sets collected by other agencies in the region.

ECMI Host Installation

Fort Benning, GA, has been selected as the first site for implementation of the SEMP. Fort Benning is located in west-central Georgia south of the city of Columbus, GA, and east of Phenix City, AL. It occupies approximately

73,813 hectares (ha) in Chattahoochee, Muscogee, and Marion Counties, Georgia, and Russell County, Alabama. Figure 1 shows Fort Benning and other selected military installations in a regional ecological context. The ecological units in Figure 1 are those proposed by the U.S. Forest Service (Keys et al. 1995) for the southeastern United States. Fort Benning occupies a transition zone between two ecological units: (1) the Coastal Plains and Flatwoods, Lower Section; Sand Hills Subsection, and (2) the Coastal Plains, Middle Section; Upper Loam Hills Subsection. Several streams flowing onto Fort Benning from the north have their headwaters in the ecological unit immediately to the north, the Southern Appalachian Piedmont Section; Midland Plateau Central Uplands Subsection (Figure 1).

Fort Benning is a U.S. Army Training and Doctrine Command installation (Department of the Army 1994). U.S. Army Forces Command units constitute about 50 percent of military personnel on post. These units include the 3rd Brigade, 3rd Infantry Division (Mechanized), and the 36th Engineer Group (Department of the Army 1994).

The general character of the Fort Benning landscape is portrayed in Figures 2–4. The installation exhibits moderate relief, a near classic dendritic drainage pattern, and includes an area of the Chattahoochee River floodplain in the southwest corner (Figure 2). The surface soil is primarily loamy sand to the north and sandy loam to the south (Figure 3). The ecological units shown in Figure 1 are reflected as gross differences in surface soil texture across the installation. The land cover is dominated by a variety of evergreen, deciduous, and mixed forest types (Figure 4). Approximately 11,371 ha are in cantonment and restricted areas.

Monitoring Plan Design

The two fundamental decisions required during the monitoring design process were:

a. What to monitor (thematic component).

b. Where to monitor (spatial component).

These decisions were approached through a process that included a variety of activities including:

a. Review of scientific and technical literature.

b. Review of similar established monitoring programs.

c. Workshops with scientific subject area specialists.

d. Workshops with Fort Benning land managers and trainers.

e. Workshops with SEMP research teams.

f. Inventory and review of existing data for Fort Benning and the surrounding area.
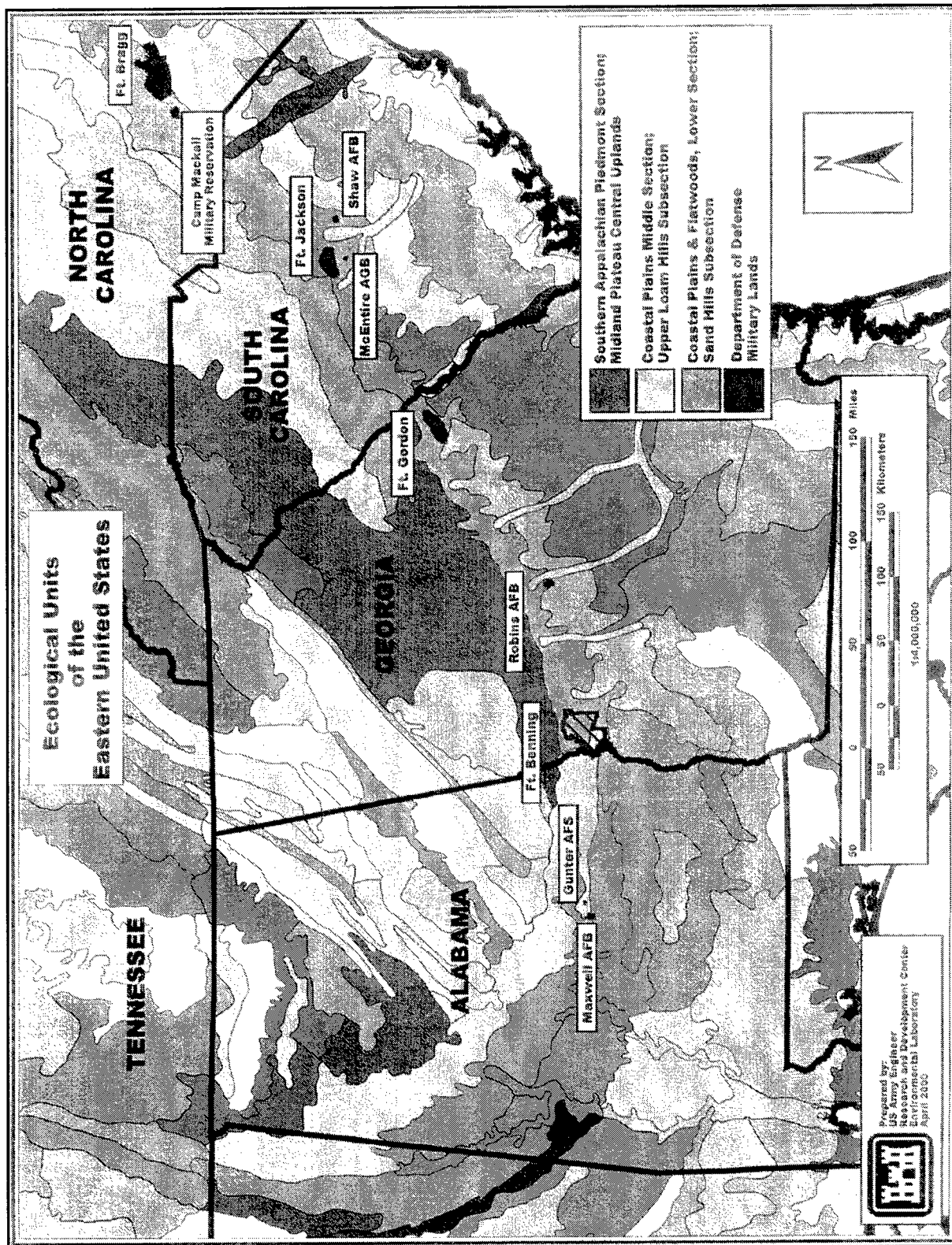
Figure 1. Regional ecological setting of Fort Benning, GA, and selected other DOD installations. Ecological units from Keys et al. (1995)
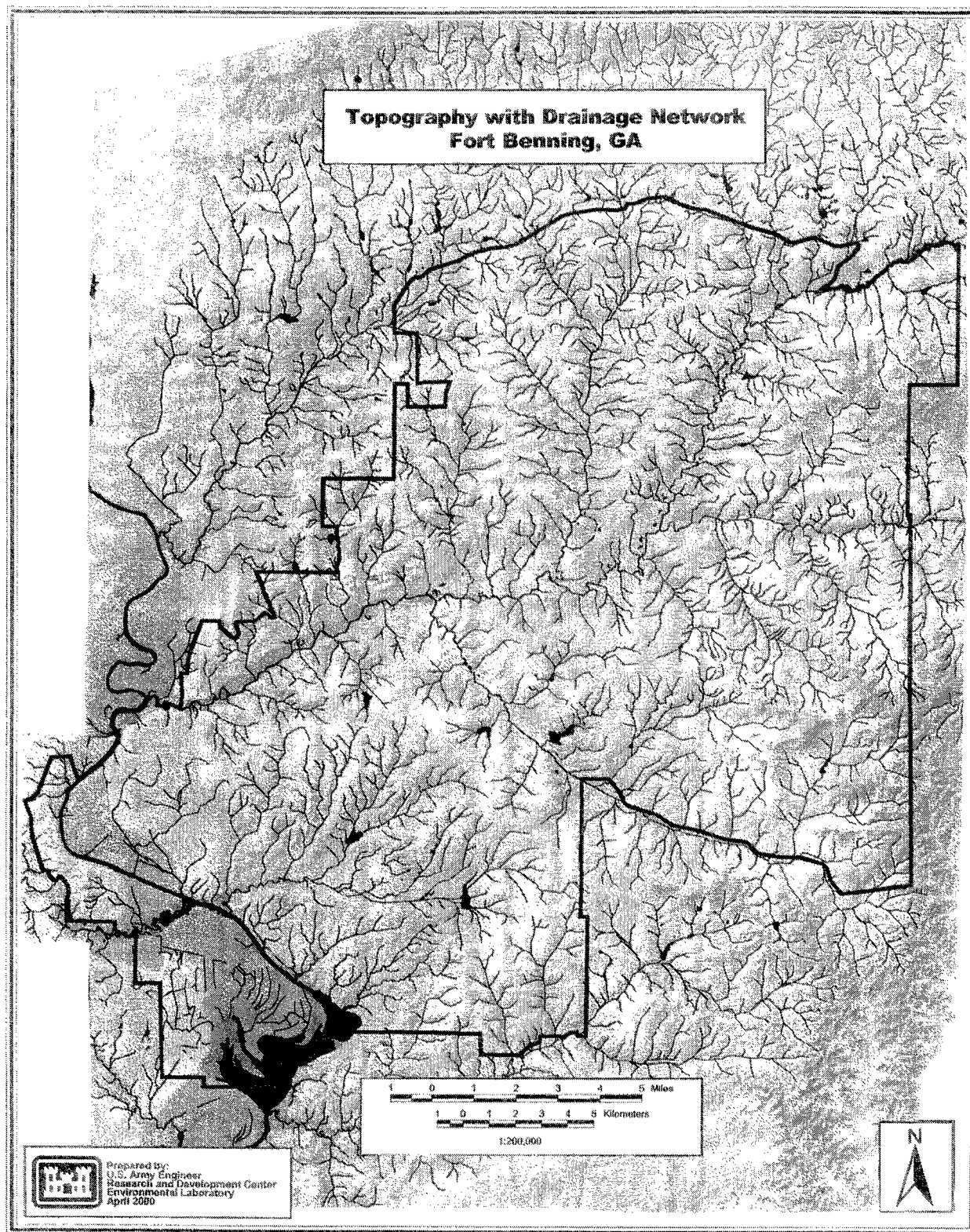
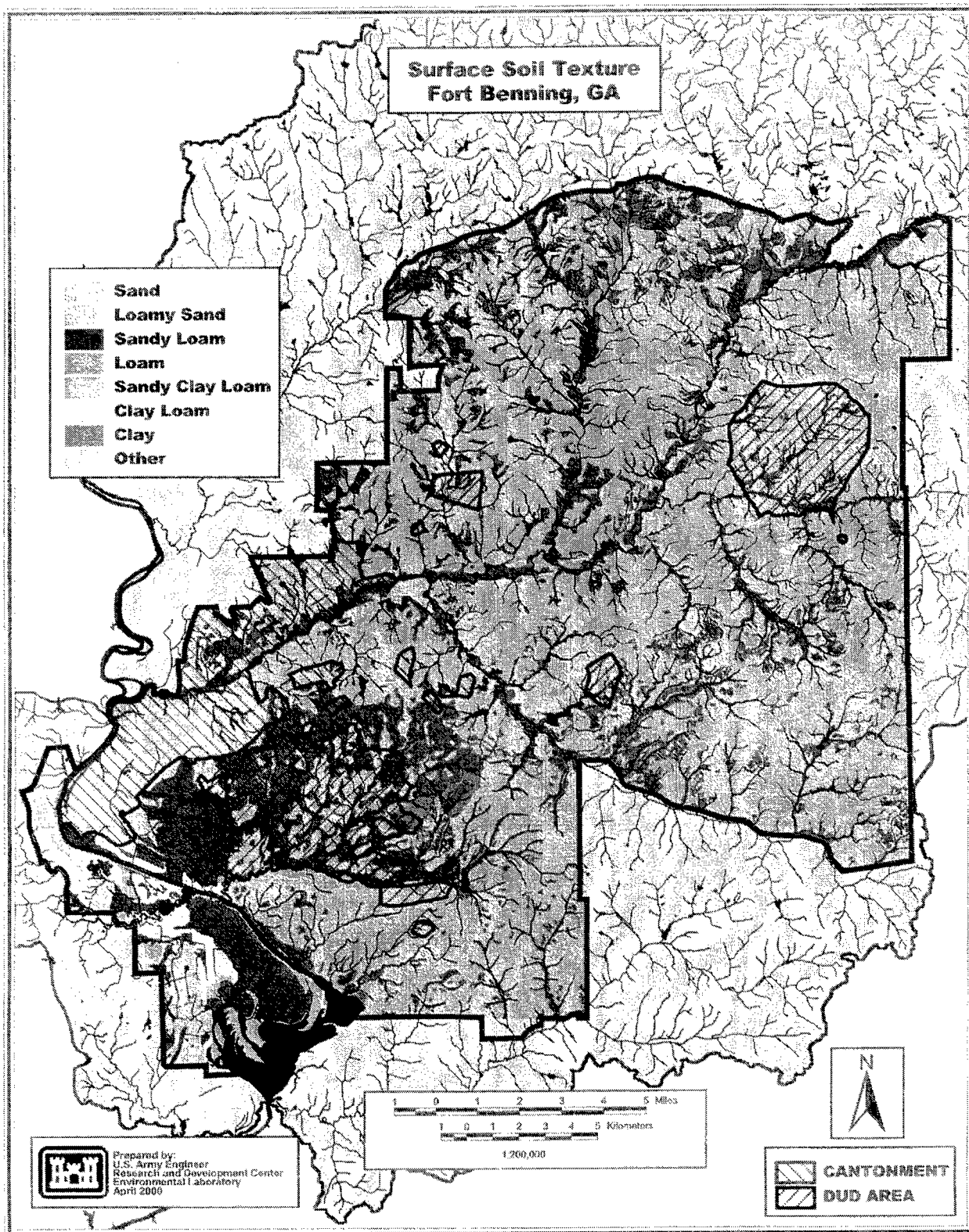Figure 2. Fort Benning topography and drainage network

Figure 3.   Fort Benning surface soil textures
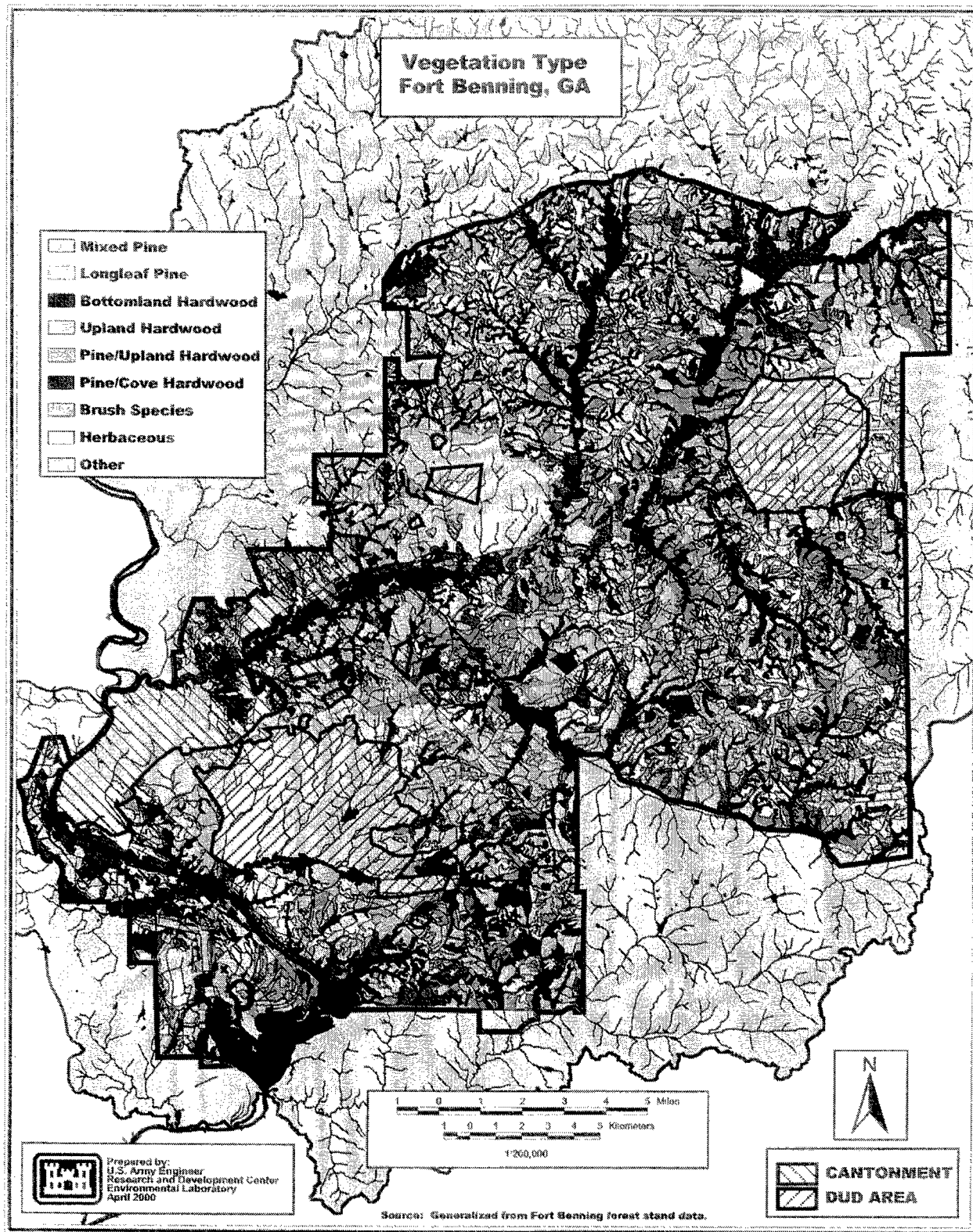
Figure 4.   Fort Benning vegetation types. The vegetation types are generalized from the Fort Benning timber management program forest stand types

Chapter 2   Ecosystem Characterization and Monitoring Initiative

   g.   Ecological characterization of Fort Benning landscape based on available data, including:

       (1) Development of a digital elevation model and detailed stream network.

       (2) Ordering of the stream network.

       (3) Delineation of watersheds.

       (4) Enhancement of the available surface soil database.

       (5) Preliminary landcover spatial pattern analysis.

   h.   Preliminary selection and review of variables for monitoring.

   i.   Formal peer review of the initial draft monitoring plan (ECMI V1.0).

   j.   Review of modified and revised monitoring plan (ECMI V2.0).

The plan currently under review and summarized herein is ECMI V2.1.

Monitoring Components

The literature review and assessment of ongoing monitoring programs indicated that the "what to monitor" question is strongly influenced by the prevailing conceptual models of an ecosystem. In the broadest context, SEMP is conducting investigations in the arenas of "ecosystem" science and "ecosystem" management as applied to military landscapes. In the scientific literature, ecosystems are generally discussed in terms of the *processes* that sustain them, the *properties* they exhibit, and the *functions* they provide. The research, characterization, and monitoring activities under the SEMP umbrella were conceived and developed around this process, property, and function conceptual model of ecosystems. The key ecosystem processes, properties, and functions for which fundamental understanding is required to meet DOD goals of sustainability are identified and discussed by Christensen et al. (1996) and are listed in Table 1.

One challenge of ECMI is to design a long-term monitoring package whose data products can be interpreted in terms of these ecosystem processes, and also be useful in an ecosystem management operational context.

The ECMI monitoring components were selected in the context of these ecosystem concepts. The currently proposed thematic components (what to monitor) for the ECMI at Fort Benning are also presented in Table 1. Table 1 illustrates the relationship of the monitoring components to the key ecosystem processes and properties and provides a brief description of the component. A more detailed description of each component is provided in Appendix A.

For discussion purposes, the monitoring components are grouped in Table 2 as addressing either the terrestrial or aquatic subsystem. This grouping facilitates discussion of the monitoring plan in practical terms. Other information in Table 2 is discussed in the following sections.

Table 1
Relation of ECMI Thematic Monitoring Components to Key Ecosystem Processes and Properties

Ecosystem Processes and Properties	ECMI Thematic Monitoring Components	Component Description
Hydrologic flux and storage	Meteorology	Permanent, automated, full-feature weather stations
	Surface water flow	Automated recorders; depth and velocity measured, stage-discharge calibrated
	Groundwater	Automated recording shallow wells; level only
Biological productivity	Net primary productivity	Regional images produced by National Aeronautics and Space Administration (NASA)
	Aquatic productivity	Field measurements of periphyton primary productivity rate and algal food quality index
	Woody productivity	Field measured; rate calculated from diameter at breast height (dbh); height, crown, species relationships; co-located with erosion/deposition transects
	Vegetation density	Standard vegetation density indices derived from Landsat Thematic Mapper imagery
Biogeochemical cycling and storage	Surface water quality	Automated recorders; temperature, pH, nitrate, turbidity, dissolved oxygen, specific conductivity
	Soil erosion/deposition	Field measured erosion/deposition rates along permanent transects; co-located with woody productivity plots
Decomposition	Aquatic decomposition	Field measurements of weight loss of submersed litter bags; decomposition rate, litter food quality, litter fragmentation rate
Maintenance of biological diversity	Aquatic macroinvertebrates	Environmental Protection Agency (EPA) standard Rapid Bioassessment Protocol (RBP) for benthic macroinvertebrates
	Land cover type	National Vegetation Classification System formation level land cover map derived from Landsat Thematic Mapper imagery
	Land cover pattern	Fragmentation/spatial pattern metrics calculated from land cover map

Note: Key ecosystem processes and properties are defined by Christensen et al. (1996). Individual monitoring components are described in the Summary Sheets in Appendix A.

Spatial Context of Monitoring Components

Figure 9 illustrates a potential set of joint management-monitoring-research watershed units for Fort Benning. The unit boundaries are watershed-based and were established in cooperation with the Fort Benning Natural Resources Management Branch and the Fort Benning Directorate of Operations and Training. The intention for designating the watershed units was to provide a spatial landscape structure that has the potential to support long-term monitoring and land management activities in an (future) ecosystem management context.

The ECMI monitoring plan is watershed-based. This is in support of the Fort Benning Integrated Natural Resource Monitoring Plan (INRMP) currently under development. The INRMP is evaluating several ecosystem management frameworks. One is based on vegetation-defined ecological groups, and one is based on watersheds. The watershed-based framework includes a strategy for evolving from a parcel-based spatial framework for land management (training

Table 2
Terrestrial and Aquatic Themes of ECMI Monitoring Components[1]

Component	Regional	Installation	Watershed	Number of Sites	Percent of Installation	Note[2]
Terrestrial						
Land cover type	*				100	
Land cover pattern	*				100	
Vegetation density	*				100	
Net primary productivity	*				100	
Erosion/deposition		*	*	90	3	2 watersheds + 30 LCTA
Woody productivity		*	*	90	3	2 watersheds + 30 LCTA
Aquatic						
Meteorology		*	*	10	100	
Surface hydrology flow			*	15	42	13 watersheds + Upatoi Creek + Uchee Creek
Surface water quality			*	6	14	5 watersheds + Upatoi Creek
Aquatic macroinvertebrates			*	14	42	13 watersheds + Uchee Creek
Groundwater level			*	5	14	5 watersheds
Aquatic productivity			*	5	14	5 watersheds
Aquatic decomposition			*	5	14	5 watersheds

[1] The three spatial scales of regional, watershed, and installation are described in the text. The symbol * indicates that the data collected for the component are applicable to the indicated scale. The individual monitoring components are described in the Summary Sheets in Appendix A. The distributions of monitoring sites across the installation are shown in Figures 5-8.
[2] LCTA = Land condition – trend analysis.

compartment, forest stand, etc.) to a watershed-based spatial framework. The concept is for land management units, long-term monitoring units, and ecosystem research units to have compatible spatial frameworks. However, as Omerick and Bailey (1997) discuss, watersheds and ecoregions (or ecosystems) are not necessarily synonymous, and some justification for adopting the watershed approach for ECMI is warranted.

Ecosystems are generally discussed in the abstract as complex combinations of biotic and abiotic factors with examples given such as long-leaf pine forest ecosystem or shallow lake ecosystem. However, to design a *practical* and *quantitative methodology* to characterize the state of ecosystem properties and to monitor the long-term ecological condition of an installation, a spatial framework and definite boundaries must be established around the system to be studied (Aber and Melillo 1991).

For ECMI, these boundaries must be easily identifiable, the framework must have relevance to scientific research, and both the boundaries and the framework should be compatible with future adaptive management activities. The watershed
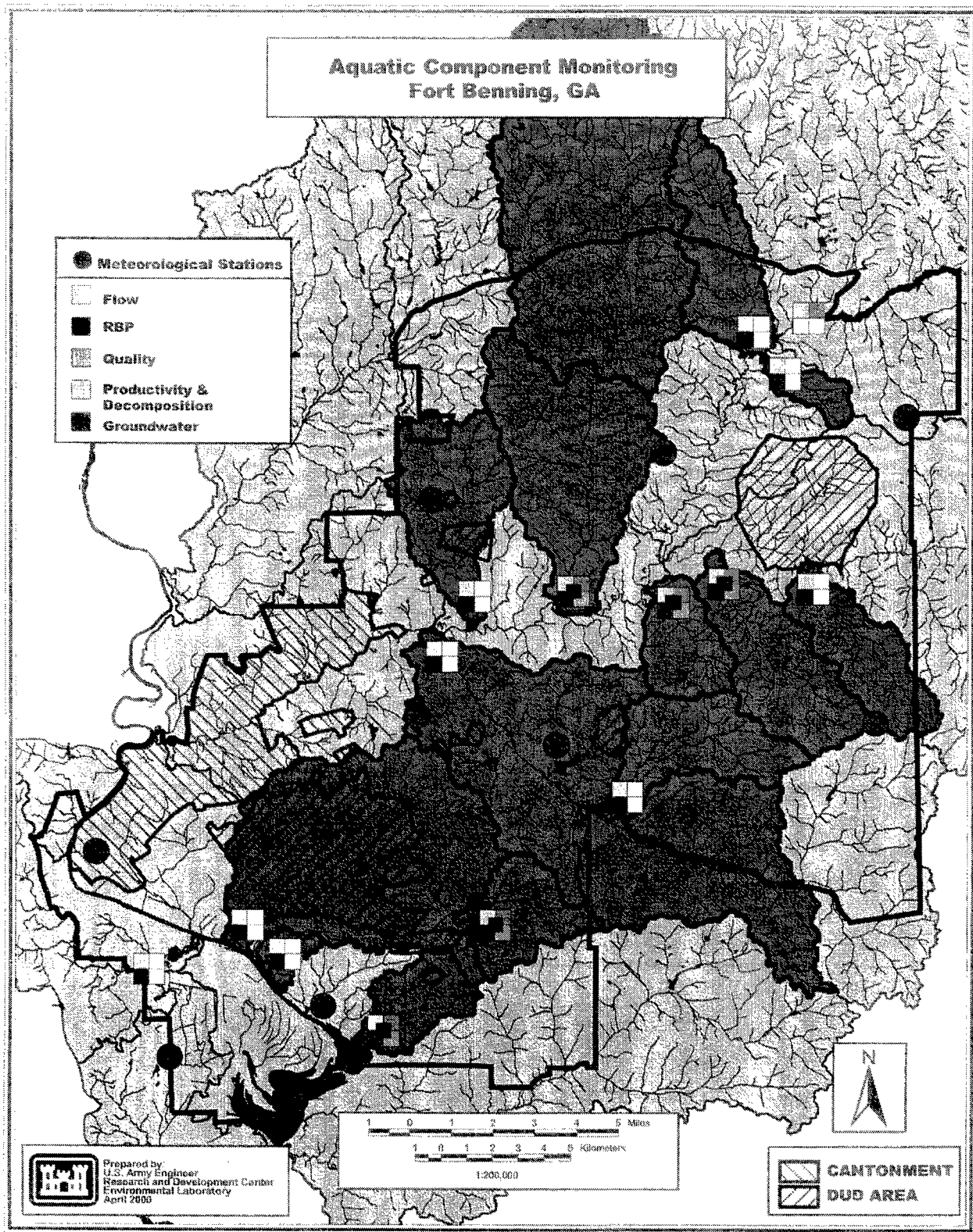
Figure 5.   Aquatic component monitoring locations
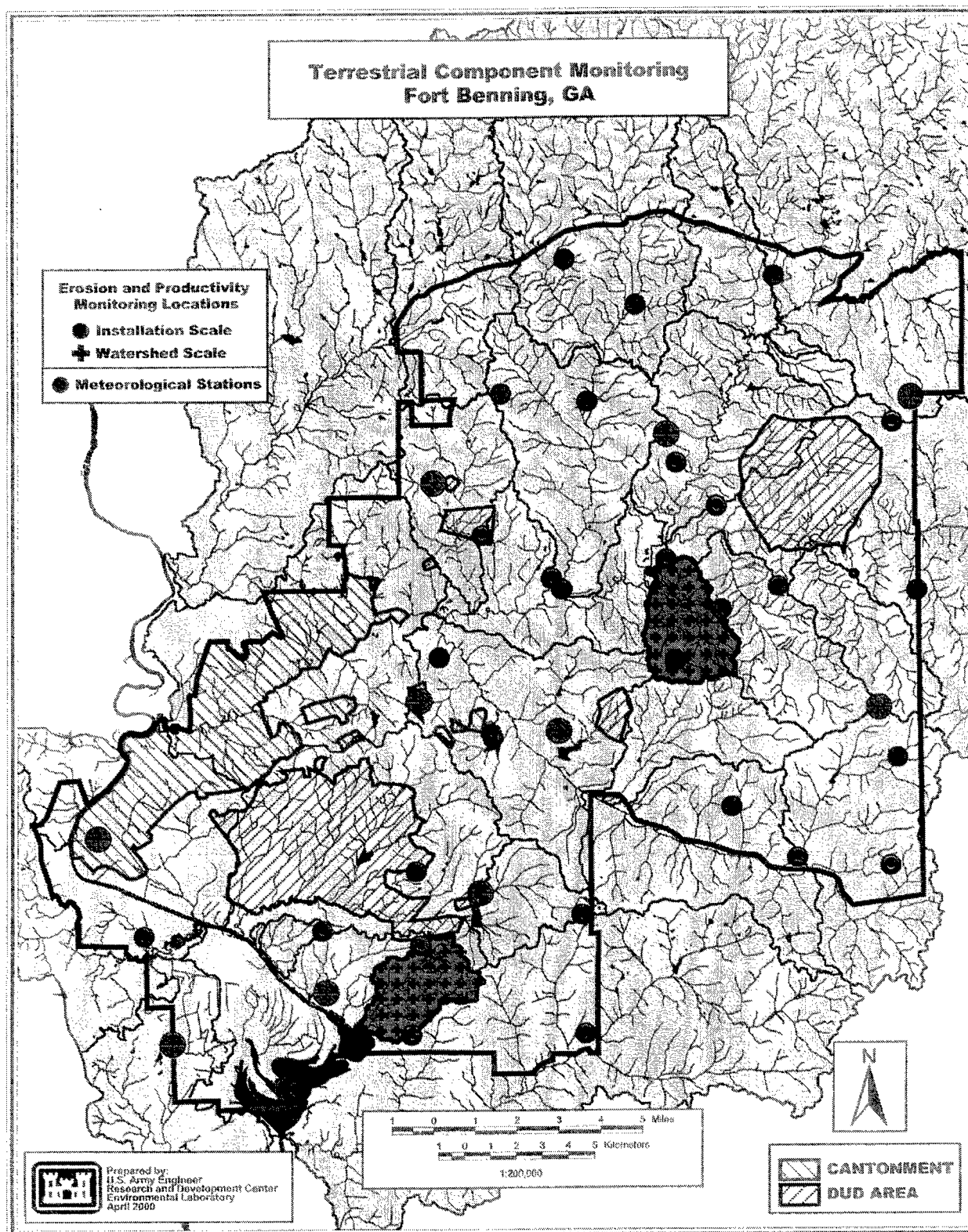
Figure 6.   Terrestrial component monitoring locations
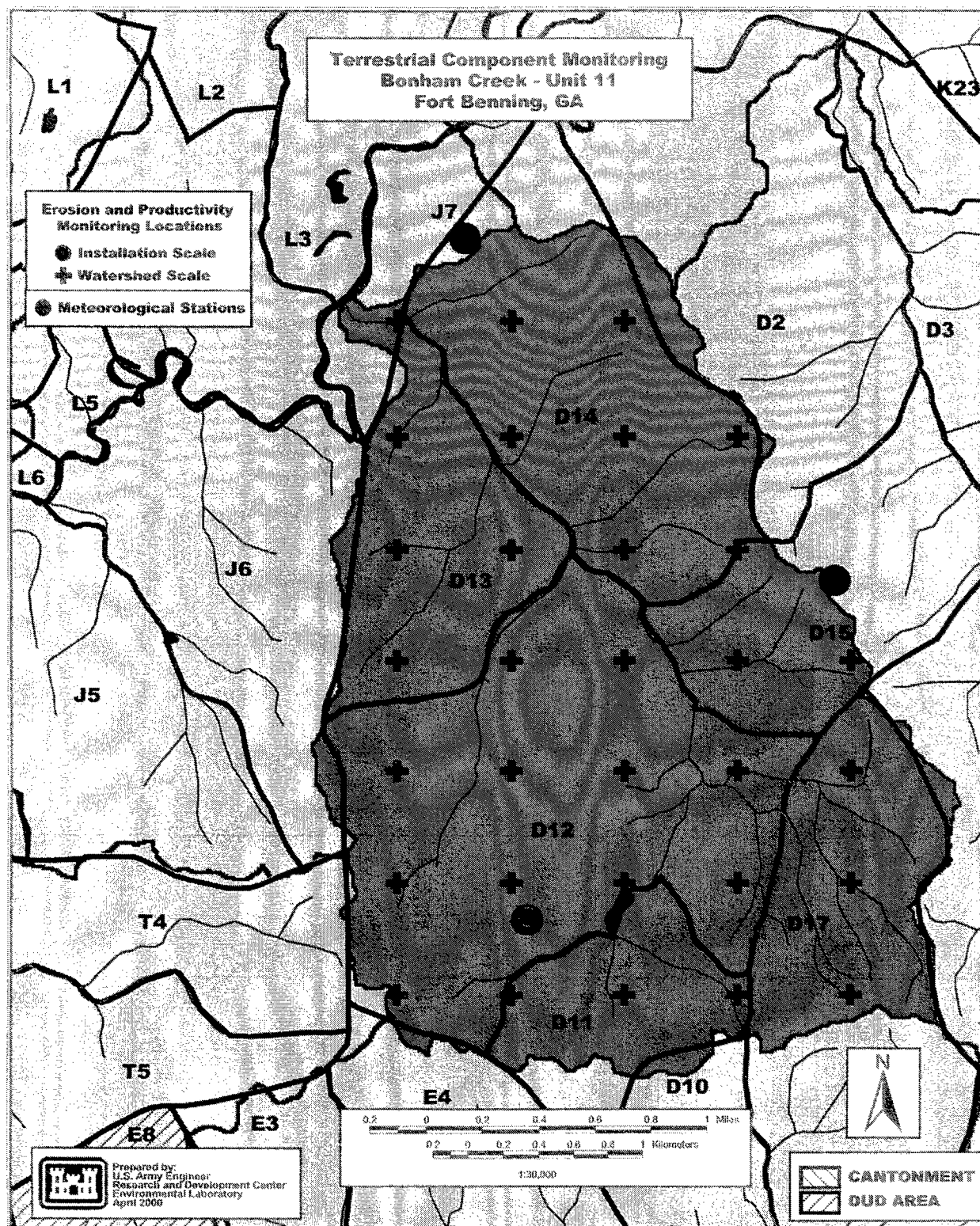
Figure 7.   Detail of terrestrial component monitoring, Bonham Creek
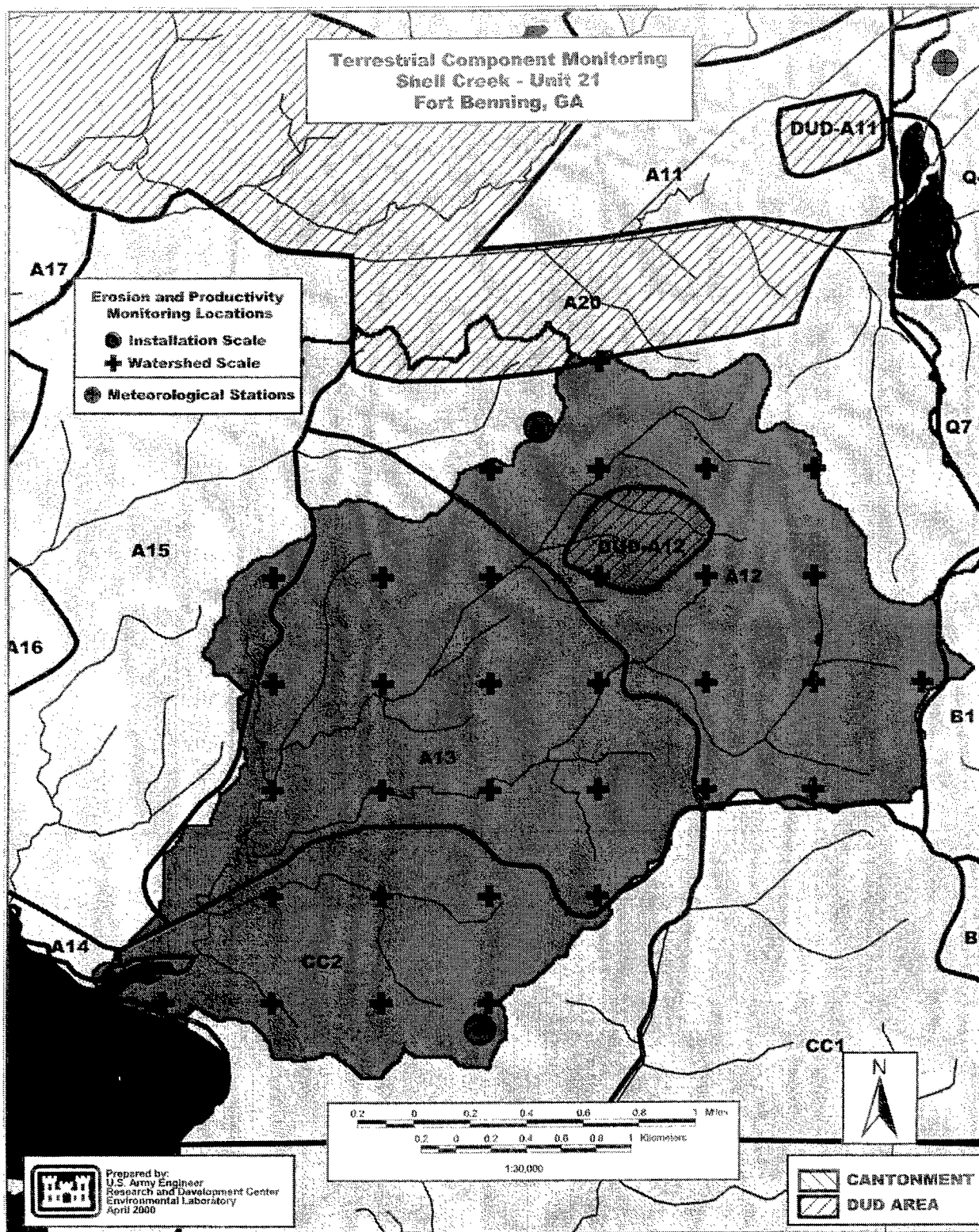
Figure 8.   Detail of terrestrial component monitoring, Shell Creek
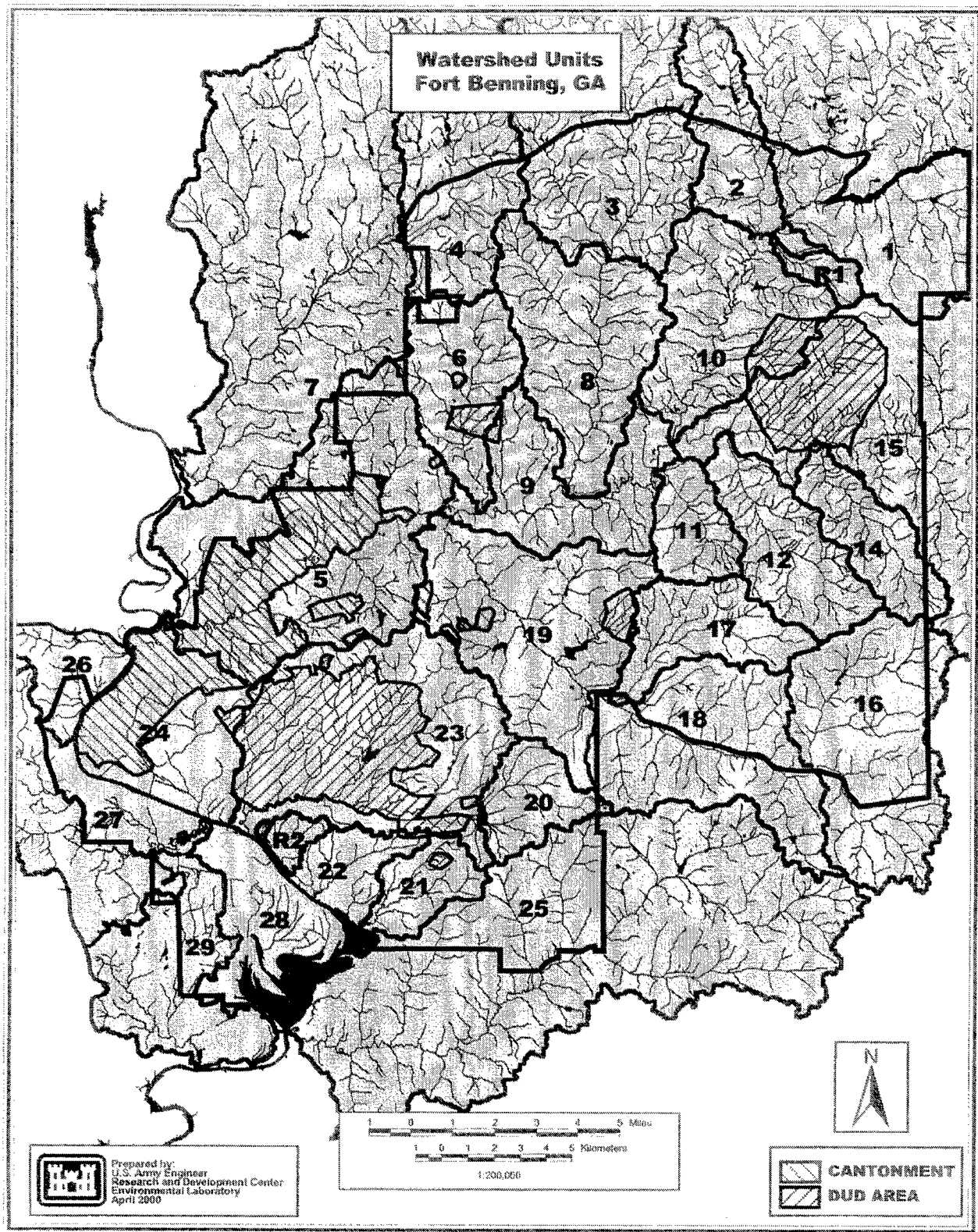
Figure 9.   Watershed scale as defined for the ECMI at Fort Benning, GA. The figure depiscts watershed-
            based potential monitoring units. These watersheds represent landscape units that may serve
            as joint monitoring – land management units in an ecosystem framework

concept fits several of these requirements and has been extensively used because of the importance of water balances within ecosystem studies.

A watershed is a topographically defined unit of landscape space in which all the precipitation falling within the defined space leaves in a single stream (Aber and Melillo 1991). As physical units of space, watersheds are definable, identifiable, and scaleable. Except in areas of extremely low local relief (such as the Chattahoochee floodplain) or severely disrupted surface drainage (karst or glaciated knob and kettle), the geographic limits of watersheds can be identified and their boundaries established using commonly available geospatial data.

The utility of watersheds as the spatial framework for ecosystem research has been established over the past 15 years. Herrmann (1997) provides a brief review of the watershed ecosystem approach to research and long-term monitoring and a summary of the collective experiences of these programs. Agencies which have adopted a watershed-based approach to long-term monitoring and ecological research, include U.S. Department of Agriculture, U.S. Forest Service, National Park Service, U.S. Geological Survey, U.S. Environmental Protection Agency, and National Science Foundation.

Three spatial contexts are discussed in the monitoring plan, referred to as regional, installation, and watershed scales (Table 2). Two of these scales - regional and watershed - are watershed-based. The regional scale, as defined in this report, is that portion of the USGS Hydrologic Unit Code # 03130003 shown in Figure 10. Watershed scale, as defined in this report, refers to any of the watershed-based units shown in Figure 9. Installation scale, as defined in this report, coincides with the Fort Benning installation boundary as shown in Figure 11. Figure 11 also shows the Land Condition - Trend Analysis (LCTA) sampling plots. LCTA is an established installation-scale monitoring program.

Table 2 indicates, for each monitoring component, the spatial context(s) addressed by the component, the number of monitoring sites, and the percent of the installation represented by those sites.

Monitoring Locations

To assist in determining where monitoring will be conducted, the range of conditions represented by the defined watershed units was characterized from available data. Some of the characterization data for the selected watersheds are given in Table 3. The watersheds were characterized by the following:

a. Total area of watershed.

b. Area of watershed within the installation.

c. Stream density (for whole watershed unit).

d. Road density (for portion of watershed within installation).

e. Number of stream crossings (within installation).

f. Number of LCTA plots.
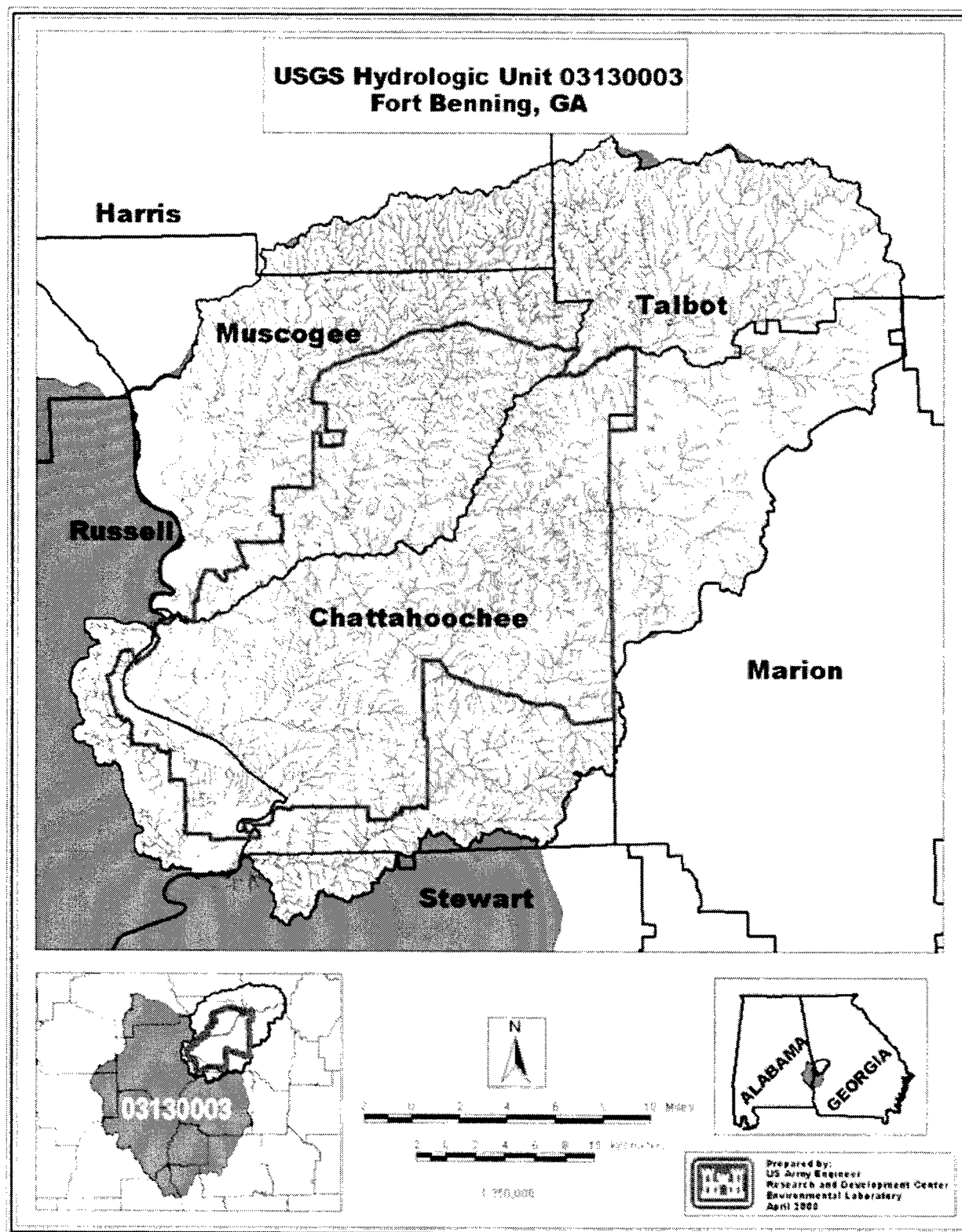
Figure 10. Regional scale as defined for the ECMI at Fort Benning, GA. The portion of USGS hydrologic unit number 03130003 shown in this figure defines the limit of regional scale monitoring components. The surface drainage network shown is from USGS 1:24,000-scale topographic maps. County names are indicated.
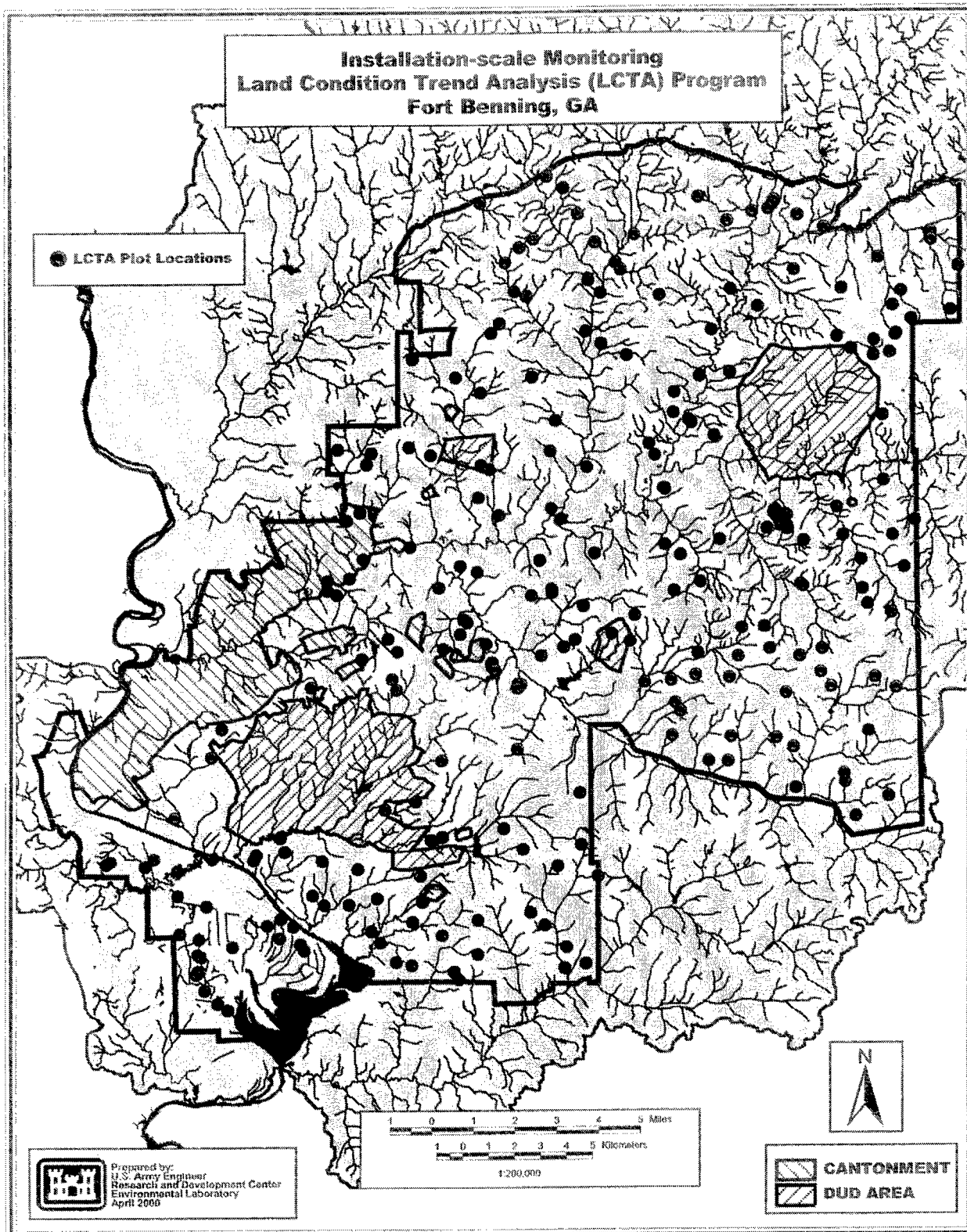
Figure 11. Installation scale as defined for the ECMI at Fort Benning, GA. The installation boundary defines the limit of installation-scale monitoring components. The figure also shows the distribution of LCTA Program monitoring plots. LCTA is an established monitoring program at the installation scale.

Table 3
Characterization of Selected Watersheds at Fort Benning, GA[1]

	Cox (Unit 2)	Upper Randall (Unit 3)	Wolf (Unit 6)	Lower Randall (Unit 8)	Bonham (Unit 11)	Sally (Unit 12)	Lil' Pine Knot (Unit 14)	Halloca (Unit 17)	Upper Ochillee (Unit 18)
Total area, Km2	21.0	91.2	24.5	42.7	12.7	25.3	18.0	21.0	46.9
Installation area, Km2	11.2	31.7	23.0	42.7	12.7	25.3	16.5	20.8	19.2
Stream density, Km/Km2	2.3	2.6	1.9	2.0	2.3	2.6	2.4	1.9	1.8
Road density, Km/Km2	2.5	2.7	2.4	3.3	3.0	2.9	2.2	2.4	2.7
Stream crossings	10	28	17	59	15	39	11	18	16
LCTA plots	3	10	6	10	4	24	8	6	8
Soil Type (Percent area)									
Sand	0	0	1	0	3	6	1	1	0
Loamy sand	51	59	70	74	66	43	71	24	45
Sandy loam	45	34	28	25	17	21	18	26	23
Loam	4	7	1	1	0	0	1	2	0
Sandy clay loam	0	0	0	0	14	30	9	47	32
Clay loam	0	0	0	0	0	0	0	0	0
Clay	0	0	0	0	0	0	0	0	0
Variable	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0
Water	0	0	0	0	0	0	0	0	0
Vegetation (Percent area)									
Mixed pine	48	56	31	49	36	44	40	60	58
Longleaf pine	1	4	2	7	4	4	1	2	2
Bottomland hardwood	32	26	12	24	18	22	20	20	14
Upland hardwood	0	4	0	2	8	12	2	4	1
Pine/upland hardwood	2	5	9	7	20	11	27	2	8
Pine/cove hardwood	0	4	3	3	2	4	7	6	8
Brush	11	1	0	2	5	1	0	6	6
Herbaceous	0	0	0	1	1	0	0	0	0
Other	6	0	43	5	6	2	3	0	3
Military Training (Percent area)									
Light maneuver area	21	28	91	66	1	0	0	50	100
Heavy maneuver area	79	72	0	3	99	100	100	50	0
Other	0	0	9	1	0	0	0	0	0

[1] "Units" refer to key in Figure 12.

(Continued)

Table 3 (Concluded)

	Lower Ochillee (Unit 19)	Upper Oswichee (Unit 20)	Shell (Unit 21)	Lower Oswichee (Unit 23)	Lois (R-1) (Within Unit 10)	Lizzie (R-2) (Within Unit 22)	Randall (W-1) (Units 3 & 8)	Ochillee (W-2) (Units 17, 18, & 19)
Total area, km2	54.0	13.8	11.4	70.0	4.0	3.4	133.9	121.9
Installation area, km2	54.0	13.5	11.4	70.0	4.0	3.4	74.4	94.0
Stream density, km/km2	1.6	1.9	2.2	2.1	2.3	2.8	2.4	1.7
Road density, km/km2	3.2	2.5	1.7	1.7	1.7	1.1	3.1	2.9
Stream crossings	49	14	6	61	3	2	87	0
LCTA plots	32	3	6	10	1	2	20	0
Soil Type (Percent area)								
Sand	6	0	0	23	10	0	0	4
Loamy sand	48	7	0	1	79	3	68	42
Sandy loam	24	13	4	58	10	19	29	24
Loam	2	3	4	4	0	0	3	2
Sandy clay loam	19	76	90	11	1	78	0	27
Clay loam	0	0	0	0	0	0	0	0
Clay	0	0	0	3	0	0	0	0
Variable	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0
Water	1	1	2	0	0	0	0	1
Vegetation (Percent area)								
Mixed pine	48	44	57	22	6	14	52	53
Longleaf pine	8	1	4	4	15	52	6	6
Bottomland hardwood	17	35	27	7	18	2	25	17
Upland hardwood	2	1	1	0	28	0	3	2
Pine/upland hardwood	14	10	3	2	13	3	6	10
Pine/cove hardwood	4	5	7	3	17	14	3	5
Brush	2	4	1	1	2	5	1	4
Herbaceous	1	0	0	0	0	0	1	0
Other	4	0	0	61	1	10	3	3
Military Training (Percent area)								
Light maneuver area	94	98	95	90	0	100	50	85
Heavy maneuver area	0	0	0	0	100	0	50	11
Other	6	2	5	10	0	0	0	4

g. Soil type distribution (within installation).

h. Vegetation type distribution (within installation, based on forest stand types).

i. Level of military use (from Range and Training Land Program) (U.S. Army Engineering Support Center 1997).

Two other watershed characteristics important in the ECMI design were

a. Accessibility (e.g. presence of DUD or live fire areas).

b. Potential for off-base influence (percent of drainage area outside base boundary).

During the design process, two factors emerged to be of particular interest to the Fort Benning land managers. These were soil type and level of military use. Figure 12 shows the distribution of the watersheds included in the monitoring plan in the context of these two factors.

Aquatic Component Monitoring Locations

The distribution of aquatic component monitoring activities is shown in Figure 5. Aquatic monitoring activities, other than meteorology, are sited near the outlet of the selected watershed units. Measurements taken in these outlet locations represent spatially integrated values for the drainage area upstream of the site. Summary sheets describing each monitoring component in more detail are presented in Appendix A. References to installation goals given in the summary sheets are defined in Appendix B.

Meteorology

Ten meteorological stations are distributed across the installation. They are positioned to represent the entire installation but do not correspond to specific watershed units.

Surface water flow

Surface flow will be monitored in 15 locations. These locations are indicated in Figure 5. Thirteen of these locations represent watershed units. One is located on Upatoi Creek near the northern installation boundary, and one is located on Uchee Creek near the western installation boundary.

Surface water quality

Surface water quality will be monitored in six locations indicated in Figure 5. Five of these represent watershed units. The sixth is located on the Upatoi Creek near the northern installation boundary.

Surface Soil Textures
Coarse Soils
Sand
Loamy Sand
Fine Soils
Sandy Loam
Loam
Sandy Clay Loam
Clay Loam
Clay

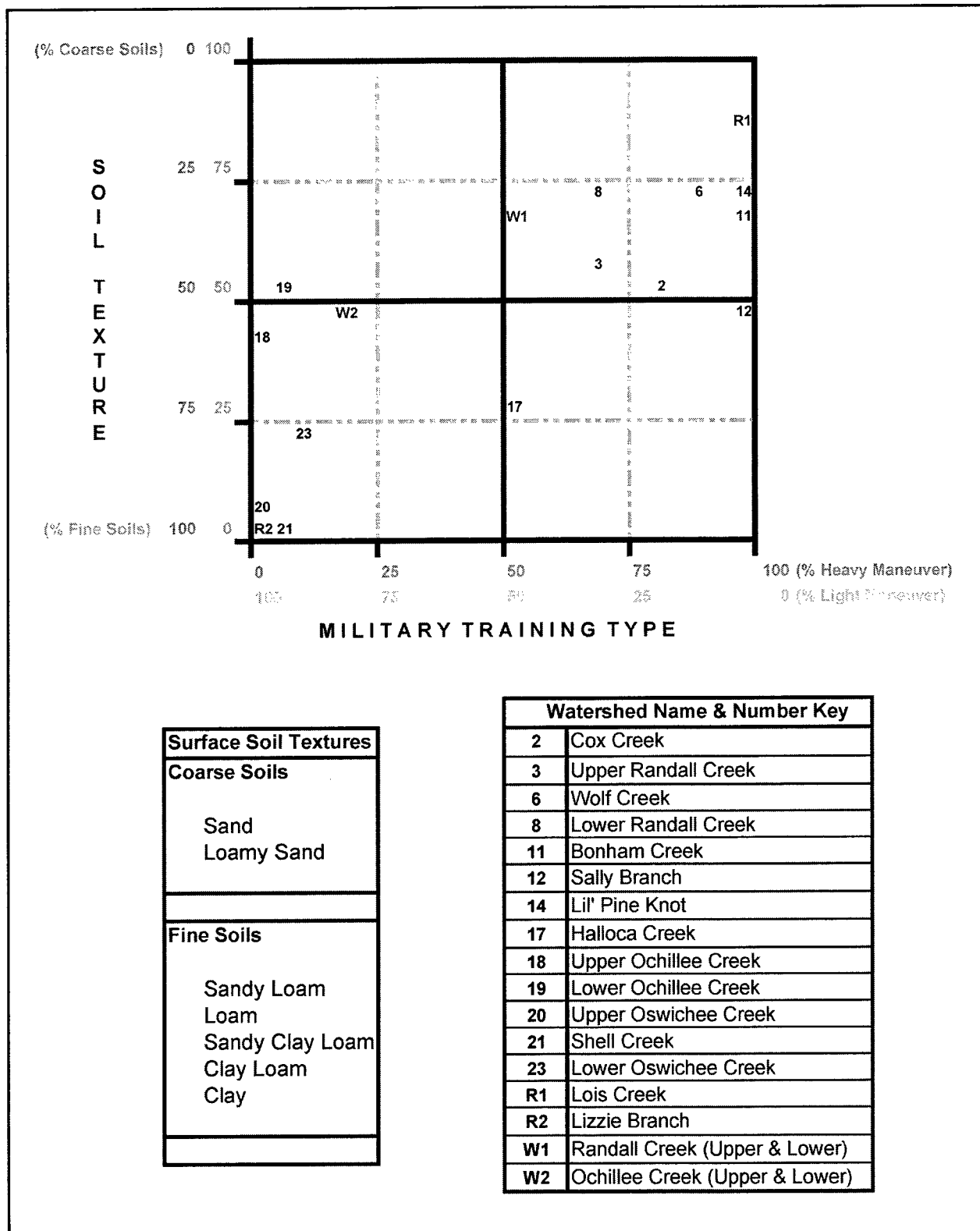| Watershed Name & Number Key	
2	Cox Creek
3	Upper Randall Creek
6	Wolf Creek
8	Lower Randall Creek
11	Bonham Creek
12	Sally Branch
14	Lil' Pine Knot
17	Halloca Creek
18	Upper Ochillee Creek
19	Lower Ochillee Creek
20	Upper Oswichee Creek
21	Shell Creek
23	Lower Oswichee Creek
R1	Lois Creek
R2	Lizzie Branch
W1	Randall Creek (Upper & Lower)
W2	Ochillee Creek (Upper & Lower)

Figure 12. Distribution of selected watersheds as a function of surface soil texture and military training types

Rapid Bioassessment Protocol (RBP) - Aquatic macroinvertebrates

RBP will be conducted at 14 locations indicated in Figure 8. These locations represent watershed units with the exception of the one on the Uchee Creek in Alabama.

Aquatic productivity and decomposition

These components will be monitored together at five locations indicated in Figure 5. These sites represent watershed units.

Groundwater level

The shallow alluvial groundwater level will be monitored at the five surface water quality sites that represent watershed units. These locations are indicated in Figure 5. The groundwater monitoring component is designed to allow quantification of the groundwater contribution to surface flow for five watersheds. Only groundwater level is monitored. No groundwater quality monitoring is proposed.

Terrestrial Component Monitoring Locations

The terrestrial component monitoring from remotely sensed data will be conducted at a regional scale for the entire USGS hydrologic unit area as indicated in Figure 10. Terrestrial component monitoring focuses on monitoring regional land cover characteristics. Summary sheets describing each monitoring component in more detail are presented in Appendix A.

Net primary productivity

Regional net primary productivity will be obtained from the NASA Earth Observing System satellite. ECMI will acquire these data directly from NASA for the Fort Benning region when available.

Land cover type and vegetation density indices

Two other remotely sensed terrestrial components will be developed through processing of Landsat Enhanced Thematic Mapper imagery. Components to be derived directly from the imagery are land cover type and vegetation density indices.

Land cover pattern

A third regional scale terrestrial component, land cover pattern, will be derived from the land cover type mapping using existing geostatistical processing techniques.

Soil erosion/deposition and woody productivity

The monitoring locations for the two remaining terrestrial components - soil erosion/deposition and woody productivity - are shown in Figure 6. Soil erosion and woody productivity monitoring are always co-located. The sites are in two watersheds and at 30 randomly selected LCTA plots. Each watershed-scale sampling design consists of 30 sites on a systematic grid initiated at a random starting point. The 30 LCTA plots (Figure 6) were selected randomly from those LCTA sites reporting the presence of woody vegetation. As an extension of the LCTA sampling design, these monitoring sites can be considered an installation-wide sample. Figures 7 and 8 show a detailed view of the terrestrial component sampling sites for the two selected watersheds, Bonham Creek and Shell Creek, respectively. These watersheds represent 3 percent of the installation (Table 2).

ECMI Structure and Timeline

The ECMI is structured in three phases covering a minimum timeline of 15 years. The phases are identified in Table 4 along with a description of the activities required in each phase. The ECMI is currently in Phase I (FY99-FY01), an extended design and implementation phase.

Table 4 ECMI Phases		
Phase I, 1999-2001 Design	**Phase II, 2002-2005** Modify	**Phase III, 2006-** Maintain

Extended design, implementation, and documentation	Modification based on:
	   Initial monitoring results
	   SEMP research results
	   Land management
	     experience with indicators
		Long-term maintenance and technology upgrades

The ECMI has a modification phase built into the timeline to allow modification and adjustments during the early years (Phase II, FY02-05). Phase II provides the opportunity for potentially large adjustments to the monitoring design based on:

   a. Analysis and evaluation of early monitoring data.

   b. Results of the SEMP-focused research projects (indicators, disturbance thresholds, adaptive management).

   c. Experience of installation land managers in applying the research results and using the monitoring data.

Phase III (FY06-) continues the monitoring activities indefinitely with emphasis on maintenance of the monitoring network and periodic technology upgrades.

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Appendix A
ECMI Monitoring Component
Summary Sheets

COMPONENT: **METEOROLOGY**
SCALE: INSTALLATION

SIGNIFICANCE: Basic meteorological data are essential to all facets of the SEMP and the ECMI, providing fundamental inputs to many models, baseline information to all research activities, and direct input to land management activities. Studies related to the key processes of hydrologic flux and biogeochemical cycling are closely tied to meteorology. Basic meteorological records are also important for separating human-induced changes from long-term natural variation. Measurements of rainfall in particular are needed to understand the aquatic subsystem and quantify the hydrologic cycle. Meteorological data include basic weather data, solar insolation, and evaporation.

RELEVANCE TO INSTALLATION GOALS:[1] 1a-h, 2a-f, 5a-g, 9f, 14a, 14d

METHOD: Ten permanent, self-contained, remotely accessed meteorological stations have been established across the installation. The weather station locations are shown in Figure 5. The locations were selected to provide complete coverage of the installation. Placement considerations were terrain and site security. All meteorological stations are continuous recording, daily download. Specific data to be collected are:
    air temperature
    relative humidity
    barometric pressure
    solar radiation
    wind speed
    wind direction
    precipitation
    evaporation (one station).

PRODUCT: The product is original data as recorded. No specialized analyses are conducted.

COMMENTS:

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[1] See Appendix B for explanation of goals.

COMPONENT: **SURFACE WATER FLOW**
SCALE: WATERSHED

SIGNIFICANCE: Surface water flow characteristics are the primary data used to quantify the hydrologic response of a watershed. Hydrologic response is a measure of a watershed's ability to store and transmit rainfall and is readily impacted by land disturbances and changes in land cover. Baseline monitoring of surface water flow provides complementary data to the meteorological data for modeling water balance and rainfall-runoff dynamics of the watershed.

RELEVANCE TO INSTALLATION GOALS: 2c, 3d, 5g, 9f, 14a, 16d

METHOD: Fifteen permanent, self-contained, surface water flow monitoring stations will be established on the installation. The flow monitoring locations are shown in Figure 5. Six of these stations are integrated with water quality monitoring and nine are flow and temperature only.

The integrated stations are designed for automated recording and daily remote downloading of data. The flow-only stations are designed for automated recording and monthly field download.

PRODUCTS: The primary surface water flow data products are:
            water depth
            discharge (calculated using site characterization and field calibration procedures)
            stage-area relationships
            stage-discharge relationships

COMMENTS:

COMPONENT: **SURFACE WATER QUALITY**
SCALE: WATERSHED

SIGNIFICANCE: Water quality is diagnostic of ecosystem character and dynamics and is fundamental to the long-term productivity and sustainability of the aquatic system. Quality includes physical and chemical characteristics and often responds rapidly to ecological changes in the watershed. Water chemistry is a critical factor in monitoring where aquatic systems are impacted by human activities (Hirsch, Alley, and Wilber 1988; Briggs 1978). Water physical parameters such as temperature and turbidity often reflect disturbance to riparian areas, stream flow, or stream channel morphology (Warne and Smith 1995).

RELEVANCE TO INSTALLATION GOALS: 2c, 3d, 5g, 9f, 14a, 16d

METHOD: Basic surface water quality parameters will be monitored at six permanent monitoring stations. Five of these locations are the outlets of selected watersheds. The sixth is on Upatoi Creek near the northern installation boundary These stations are designed for automated continuous recording and remote daily download of data.
Specific data to be collected are:
>water level
>water temperature
>pH
>nitrate
>turbidity
>dissolved oxygen
>specific conductivity
>water velocity

PRODUCT: The product is original field data as recorded. No specialized analyses are performed.

COMMENTS:

COMPONENT: **AQUATIC MACROINVERTEBRATES**
              Rapid Bioassessment Protocol (RBP)
SCALE: WATERSHED

SIGNIFICANCE: Aquatic macroinvertebrates live on or just beneath stream sediments and are food for fishes, birds, amphibians, and reptiles. Many have specific habitat requirements and their presence or absence can be considered indicative of past conditions of water or sediment quality (Hynes 1966, 1970). As an alternative to inventory studies, the Rapid Bioassessment Protocol (RBP) for benthic macroinvertebrates rates the ability of an aquatic habitat to support various life functions of macroinvertebrates (Barbour et al. 1999, Plafkin et al. 1989). RBPs are cost-effective, scientifically valid, rapidly executable, environmentally benign procedures, designed to determine the overall health of an aquatic system. Results are easily understood by the scientific community and the lay public. The RBP index scores are used to monitor long-term trends.

RELEVANCE TO INSTALLATION GOALS: 2c, 3d, 5g, 9f, 14a, 16d

METHOD: RBP will be conducted at selected monitoring units near the location of the surface water monitoring site. RBP will be conducted annually in the fall of the year. RBP for benthic macroinvertebrates, Level 1, is the method chosen (Barbour, Burk, and Pitts 1999) This protocol is based on physical and topographic landscape features (stream sinuosity/pool riffle ratio, percent canopy cover, relative abundance of various species of aquatic plants), as well as qualitative macroinvertebrate samples. The relative abundance of easily identifiable major groups (crayfish, snails, immature mayflies, caddisflies) will be recorded. The RBP index scores will be calculated according to standard procedure. The macroinvertebrate data will also be used to calculate diversity and equitability (Rosenburg and Resh 1993) and establish functional feeding group designations (Merrit and Cummings 1996).

PRODUCT: Calculated variable: RBP index
                                       macroinvertebrate diversity
                                       macroinvertebrate equitability

COMMENTS:

COMPONENT: **AQUATIC PRODUCTIVITY**
SCALE: WATERSHED

SIGNIFICANCE: Even the simplest food web (green algae to aquatic insect to fish) in streams and rivers is best described by some measure of productivity or energy content (Russell-Hunter 1979). The mass of material produced by the action of sunlight (primary productivity) provides an estimate of the biomass of herbivores (aquatic insects, snails, and worms) and predators (fish) that streams could support (secondary productivity). The overall health of an aquatic ecosystem can be assessed by comparing productivity among the various trophic categories. Primary productivity rates are a function of water quality, water velocity and depth, available light, and the amount of available inorganic material. They provide one quantitative characterization of the overall health of an aquatic system.

RELEVANCE TO INSTALLATION GOALS: 2c, 3d, 5g, 9f, 14a, 16d

METHOD: Aquatic productivity will be monitored initially for two consecutive years, then in alternate years in five selected watersheds. The measurements will be made near the outlets of these watersheds close to the surface water quality monitoring sites. The method for monitoring aquatic productivity is to directly measure periphyton biomass accumulation and use these measurements to calculate benthic primary productivity. The biomass of periphyton produced on artificial hard surfaces (glass slides) is measured weekly for 3 weeks to calculate benthic primary productivity rates. Glass slides are placed at each sample site in early September to allow periphyton colonization. Each site is visited in 7 days and again at weekly intervals for 28 days, with a set of slides retrieved each week. In the laboratory all attached organisms are scraped from the slides and organic dry mass and ash-free dry mass obtained. These data are used to estimate benthic primary production (grams of organic material produced per surface area per day) over a 4-week period in the fall of each year. In addition, the ash-free dry weight is used to estimate algal food quality over the same period.

PRODUCT: Measured variables: periphyton dry mass
                                          periphyton ash-free dry mass
                Calculated variables: primary productivity rate
                                          algal food quality

COMMENTS:

COMPONENT: **AQUATIC DECOMPOSITION**
SCALE: WATERSHED

SIGNIFICANCE: Aquatic decomposition rates provide a simple, accurate, and quantitative measure of the health of an aquatic ecosystem (Reice 1980). Decomposition rates are a function of water temperature, growing season, water velocity and depth, as well as abundance and diversity of decomposing organisms. When determined in conjunction with aquatic productivity rates, they together provide a picture of the ability of the aquatic system to supply energy to higher trophic levels and to cycle materials and energy through the system.

RELEVANCE TO INSTALLATION GOALS: 2c, 3d, 5g, 9f, 14a, 16d

METHOD: Aquatic decomposition rate will be monitored in association with aquatic productivity near the locations of the water quality monitoring stations. Aquatic decomposition monitoring will be conducted initially for two consecutive years, then in alternate years. Aquatic decomposition rate is determined by recording the weight loss of leaves held in a submersed mesh bag over a 28-day period beginning in early December. At each sample site, dry leaves will be collected, weighed, and placed in mesh bags. Three replicate bags will be submersed and allowed to decompose for 28 days. The material remaining in the bags will be returned to the laboratory and dried and weighed to determine biomass lost and size distribution of the remaining litter.

PRODUCT: Measured variables: litter dry mass
                                                litter ash-free dry mass
                                                size distribution of litter
                   Calculated variables: decomposition rate
                                                litter food quality
                                                litter fragmentation rate

COMMENTS:

COMPONENT: **NET PRIMARY PRODUCTIVITY** (Remotely Sensed)
SCALE: REGIONAL, INSTALLATION, WATERSHED

SIGNIFICANCE: Net primary productivity (NPP) is the total amount of biomass accumulated, minus losses due to respiration, expressed as a rate over a defined period of time (Chapman 1976). Biological productivity is a key ecosystem process (Christensen et al. 1996) and through time has been consistently referenced as integral to sustainable land management (Cornforth 1999; Cairns, McCormick, and Neiderlehner 1993). However, NPP is a complex and highly variable process and is difficult to measure. ECMI will take advantage of the latest developments in remote sensing to provide baseline NPP data.

RELEVANCE TO INSTALLATION GOALS: 4b, 7a, 6a, 10d, 14a, 16d

METHOD: Emerging remote sensing technologies will provide routine, quantitative, standardized estimates of NPP at spatial scales suitable for ecosystem applications. The Moderate Resolution Imaging Spectrometer (MODIS) is the primary sensor onboard NASA's Earth Observing System launched 18 Dec 1999. MODIS is designed to provide data on the Earth's biospheric dynamics and includes a plan for standard development of vegetation production and NPP data on a global basis (NASA 1997). The MODIS sensor is operational, with NPP projected to be available in August 2000. The data will be available at three spatial resolutions (0.5, 1, 10 km) once every 8 days and as an annual integrated value. The data are in the form of digital raster imagery. The ECMI will acquire these data, as available, for the Fort Benning region or alternatively provide access to them through the ECMI data repository

PRODUCT: MODIS-derived NPP image data
                Examination of NPP data for necessary processing and integration with other monitoring data

COMMENTS:

COMPONENT: **LAND COVER TYPE**
SCALE: REGIONAL, INSTALLATION, WATERSHED

SIGNIFICANCE: Land cover type, density, and pattern are the primary visible expressions of underlying ecosystem structure, function, and process at all spatial scales. These ecosystem characteristics also directly reflect land management practices and land use activities. The temporal dynamics of land cover characteristics represent integrated responses to biophysical and anthropogenic impacts. At regional and landscape scales, land cover characteristics strongly affect biophysical factors such as surface albedo and sensible heat flux and play an important role in material cycling. At watershed scales, land cover is a major determinant of runoff and erosion characteristics. Habitat quality and biodiversity are directly linked to land cover. Military training mission requirements and land management goals are inseparably linked to land cover patterns.

RELEVANCE TO INSTALLATION GOALS: 1d, 1e, 2c, 4b, 6a, 7a, 10d, 14a, 16d

METHOD: Multispectral satellite imagery will be used to develop a map of land cover types, region wide, in alternate years of the program. Landsat 7 Enhanced Thematic Mapper (ETM) data will be acquired for two dates in each target year. These are December (leaf-off) and April (leaf-on). ETM data provide seven spectral bands with a 25-m spatial resolution and one panchromatic band with a 15-m spatial resolution. The land cover type classification to be used is compatible with the National Vegetation Classification Standard (NVCS) (Federal Geographic Data Committee 1997) at the formation level. The expected land cover types are listed here. Abbreviated NVCS formation names are used:

Deciduous Bottomland	Evergreen Forest Bottomland	Deciduous Shrubland
Deciduous Upland	Evergreen Forest Upland	Evergreen Shrubland
Mixed Bottomland	Planted/Cultivated	Water
Mixed Upland	Barren Soil	Herbaceous
Built up/other non-vegetated		

A statistically based accuracy assessment will be conducted on the land cover type mapping. Particular emphasis will be given to the accurate identification of barren soil within the installation and planted/cultivated areas outside the installation.

PRODUCTS: Region-wide land cover map
               Statistical summaries of land cover type distribution for the region, installation, and
               watershed scales

COMMENTS: The ETM images are also used for calculation of the vegetation indices.
               The land cover map serves as the basis for the land cover pattern analysis.
               The sequential land cover mapping and the pattern statistics can form the basis for land
               cover change mapping.

COMPONENT: **VEGETATION DENSITY INDICES**
SCALE: REGIONAL, INSTALLATION, WATERSHED

SIGNIFICANCE: Vegetation density is an important attribute of land cover and can be measured or quantified in numerous ways including biomass, leaf area index, and percent cover. Vegetation density spatial and temporal dynamics represent integrated responses to biophysical and anthropogenic impacts. Most measures of vegetation density require destructive sampling and are difficult to obtain. Various vegetation indices (VI) derived from multispectral imagery have been shown to correlate well with biophysical parameters such as biomass and leaf area index and are commonly used to establish patterns of relative vegetation density over large areas.

RELEVANCE TO INSTALLATION GOALS 1d, 1e, 2c, 4b, 6a, 7a, 10d, 14a, 16d

METHOD: VIs will be calculated using the Landsat satellite imagery collected in alternate years. The specific indices to be calculated are the Ratio Vegetation Index (RVI) and the Normalized Difference Vegetation Index (NDVI). The calculations are executed once for each image date and are relevant for all three spatial scales. This will provide a leaf-off and leaf-on vegetation density image. VIs will be calculated for the region and summarized for each spatial scale and monitoring unit. The indices are calculated as:

      RVI = NIR/RED.
      NDVI = (NIR-RED)/(NIR+RED)
      where:
      NIR= near infrared reflectance (ETM Band 4)
      RED = red reflectance (ETM band 3)

PRODUCTS: RVI and NDVI vegetation index maps.
              statistical summaries of vegetation index scores by region, installation, watershed, and cover type

COMMENTS: The sequential land cover mapping, vegetation density mapping, and land cover pattern statistics provide a strong foundation for various land cover change/dynamics research projects.

COMPONENT: **LAND COVER PATTERN**
SCALE: REGIONAL, INSTALLATION, WATERSHED

SIGNIFICANCE: Land cover type, vegetation density, and spatial pattern are the primary visible expressions of underlying ecosystem structure, function, and process at all spatial scales. These characteristics also directly reflect land management and land use activities. Land cover pattern refers to the spatial arrangement of land cover elements and is an important research focus within in the academic field of landscape ecology. A basic premise in landscape ecology is that the spatial pattern of landscape elements strongly influences ecological function and process (Forman and Gordon 1986). Horizontal landscape pattern affects wildlife populations by influencing the movement of individuals, interactions among individuals, and exposure to factors associated with edge habitats (Wiens 1989, Donovan et al. 1997; Rosenberg, Lowe, and Dhondt 1999). An important ecosystem management tool is the ability to manage land cover and land use patterns at watershed and regional scales. A large number of spatial metrics have been developed that quantify and characterize landscape patterns (McGarigal and Marks 1994). Several of these metrics provide measures of landscape-scale biological diversity patterns.

RELEVANCE TO INSTALLATION GOALS: 1d, 1e, 2c, 4b, 6a, 7a, 10d, 10h, 11c, 14a, 16d

METHOD: The land cover type map developed from ETM imagery will serve as the data upon which the pattern analysis will be performed. Spatial pattern metrics will be calculated independently for selected land cover classes at each of the three spatial scales: regional, installation, and watershed. The pattern analysis will be executed in alternate years to coincide with the land cover mapping. Specific metrics to be calculated for each land cover type are:

percent area	mean shape index
percent core area	mean nearest-neighbor distance
patch density	Shannon's diversity index (all cover types simultaneously)
edge density	fragmentation index

PRODUCTS: Spatial land cover pattern metrics for selected cover classes and three spatial scales
Comparative summaries of land cover pattern metrics by region, installation, and watershed scales

COMMENTS: The sequential land cover mapping and the pattern statistics form the basis for land cover and land pattern change analysis.

COMPONENT: **SOIL EROSION AND DEPOSITION**
SCALE: INSTALLATION, WATERSHED

SIGNIFICANCE: The soil is the common ground between the biotic and abiotic aspects of terrestrial ecosystems (Barbour, Burk, and Pitts 1980). Soil stability is one criterion for a sustainable, healthy soil system and is a prerequisite for meeting the criteria of nutrient cycling and functioning recovery mechanisms. Approaches to ecosystem characterization and monitoring must include the interrelationships of ecological processes that link soils, plants, animals, minerals, climate, water, and topography as a living system (U.S. Army Corps of Engineers 1997). Soil erosion dynamics relate closely to variations in water quality, changes to wildlife habitat quality, and the ability to train to mission standards. The problem of soil erosion on DOD lands is well documented and is a critical land management problem (Doe, Jones, and Warren 1999). As an ecosystem process, soil erosion exhibits large temporal and spatial variation and is usually studied in a numerical modeling framework. Some measured data are essential to the proper calibration and validation of these models. The purpose of the following design and method is to characterize and monitor erosion and deposition on the landscape and to provide the data necessary to develop projections into the future, by application of modeling techniques, regarding the ability of the soil resource to sustain training.

RELEVANCE TO INSTALLATION GOALS: 1, 2c, 9f, 14a, 16d

METHOD: Erosion and deposition will be characterized and monitored annually in two selected watersheds and on 30 randomly selected LCTA plots. The method is direct measurement of sequential terrain profiles along 30 5-m-long erosion and deposition transects in each watershed and one transect on each selected LCTA plot. The watershed sampling design is based on a systematic grid originating from a random starting point. This design provides the flexibility necessary to add erosion transects within the grid pattern, over time, in areas of concern or special interest using a phased sampling technique. Development of this sampling design has been coordinated with the SEMP research groups and will facilitate the integration of research results with the characterization and monitoring results. Each erosion monitoring site will be characterized during the initial implementation. Four representative soil samples will be collected at each site, and specific properties of the soil horizons will be determined in the field and the laboratory. The erosion monitoring sites are co-located with the woody productivity monitoring sites.

PRODUCTS: Surveyed surface profile per site
                    Net erosion or net deposition value per site

COMMENTS: Erosion/deposition rates periodically monitored at watershed scales will provide a status check on soil erosion and sedimentation processes and the data necessary to parameterize erosion models to project cumulative impacts of training and management scenarios. The data products from this monitoring component are the primary parameters necessary to initialize state variables for both empirical and process-type soil erosion models.

One of the primary uses of ecological process models is to capture and organize information about a system or landscape of interest. For research purposes, this process facilitates the identification of knowledge gaps and the relative importance of the gaps to accurately simulate ecological processes like erosion and deposition. For land management purposes, this process, including improvement through research, provides decision tools that allow managers to evaluate several management and mission scenarios over time and evaluate projections of the cumulative impacts. These projections can then be

checked for accuracy against future monitoring data. These results are then used to identify additional research needs as well as provide refinements to the simulation models to improve accuracy of projections. Thus, simulation modeling facilitates the process of adaptive management.

In phased sampling, data obtained in one phase (e.g. first monitoring year) is used to design or adapt the sampling network for the next phase to develop an optimal sampling network (Englund and Heravi 1994). Because it is assumed that erosion is highly variable over the Fort Benning landscape and there are areas referred to as "hot spots" that are usually undersampled using many traditional sampling designs, this phased sampling method is proposed. Statistical considerations including assumptions of randomness, spatial variation, and variation around the means using these techniques have been devised, and these techniques are the future for many areas of environmental and natural resources research and characterization and monitoring. Soil characterization properties are: moisture content, soil texture, bulk density, permeability, structure and percent organic matter.

COMPONENT: **WOODY PRODUCTIVITY** (ground-based)
SCALE: WATERSHED

SIGNIFICANCE: Primary productivity is the weight of organic matter (biomass) produced over some defined period of time through photosynthesis, which converts sunlight into plant matter (Chapman 1976). The level of primary productivity determines the amount of energy available for primary consumers (organisms that consume plants or plant materials) and for other trophic elements (secondary consumers, decomposers, etc.), and is a critical ecosystem process. Productivity is included in several national and regional monitoring programs to describe the level of sustainability of natural resources. The woody productivity monitoring data will have application to other natural resource concerns, land stewardship, and the military mission.

RELEVANCE TO INSTALLATION GOALS: 3d, 7, 13c, 2c, 4b, 7a, 14a, 16d, 21

METHOD: Woody productivity will be monitored in two selected watersheds and on 30 randomly selected LCTA plots, co-located with the soil erosion/deposition transects. The method is direct measurement of tree diameters (and associated tree form characteristics) which are used to estimate productivity using published mathematical and statistical techniques. At each monitoring site, a 0.1-ha rectangular plot (10X100 m) will be established around the erosion transect. The plot is initiated in parallel with the erosion transect and perpendicular to gradients of slope or soil features. Each woody stem >5 cm dbh will be measured to the nearest 0.1 cm with a dbh tape. The stem will be uniquely numbered, mapped, and tagged and its species, height, crown characteristics, and condition will be recorded. Ground cover, vegetation structure, and understory data will be taken on four 10-m-square subplots at each corner of the rectangle. In each selected watershed, 30 measurement plots will be established (jointly with the soil erosion transects) on a systematic grid beginning from a random starting point.

Woody productivity will be estimated using regression equations from the literature. These equations are generally based on vegetation characteristics of tree species, volume, and/or growth form. Woody productivity data will be collected every year for 3 years, then once every fourth year.

PRODUCTS: measured variables: species
                                        height
                                        crown characteristics
                                        condition
                                        dbh
                                        additional site characteristics
              calculated variables: woody productivity expressed as grams per square meter per year
                                        or as metric tons per hectare per year

COMMENTS:

Appendix B
Fort Benning Integrated Natural Resources Management Plan (INRMP) Goals and Objectives, August 1999 Draft[1]

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[1] Prepared by personnel in the Land Management Branch at Fort Benning and personnel from The Nature Conservancy.

Listed here are the Fort Benning, GA, management goals and objectives as contained in Chapter 9 of the August 1999 draft of the INRMP. Goals listed on the ECMI monitoring component summary sheets are referenced by the number-letter combinations shown here.

CHAPTER 9
MANAGEMENT GOALS AND OBJECTIVES

The management goals and objectives stated in this chapter define the broad, overall natural and cultural resources management direction for the Fort Benning Army Installation. In the context of this plan, goals are defined as the general target or end result desired to be achieved through integrated resource management. Objectives are defined as somewhat more specific targets, in some cases the attainment of which are measurable and that in all cases implementation contributes to the accomplishment of management goals. Because management goals and objectives provide management direction, they form the basis for deriving specific management guidelines (Ch. 10).

9.1 USE OF MANAGEMENT ISSUES

The management goals and objectives defined in this chapter are based on the management issues identified in Chapter 8. As new management issues arise, the sufficiency of the following goals and objectives will need to be evaluated. It is the essence of an adaptive management approach that new information leads to appropriate changes in management direction.

9.2 MANAGEMENT GOALS AND OBJECTIVES

Each management goal is followed by a list of objectives most pertinent to the accomplishment of that goal. Nevertheless, accomplishment of a particular objective often will lead to the accomplishment of multiple goals.

GOAL 1. MAINTAIN A REALISTIC TRAINING ENVIRONMENT, IN ACCORDANCE WITH AN ECOSYSTEM APPROACH, BY MANAGING FOR THE SUSTAINABILITY OF THE INSTALLATION'S NATURAL RESOURCES.

Objective a. Match, to the extent feasible, military training location, type, and intensity with the ability of the natural resources to sustain training over the long-term.

Objective b. Develop an installation-wide geospatial map that depicts the type and intensity of military land use.

Objective c. Manage natural resources to provide for a variety of realistic military training experiences, each of which may require different degrees of cover, concealment, and maneuverability, by appropriately managing soil and vegetation.

Objective d. Use applicable Best Management Practices (BMPs) (that is, of the three types of BMPs — general land-disturbing activities, forestry, and agriculture — use the most appropriate to the situation) to control soil erosion and sedimentation that may result from training activities.

Objective e. Plant vegetation in denuded areas with species, preferentially native species, appropriate to the ecology and planned use of the site.

Objective f. Rehabilitate degraded lands to sustain training capabilities and to improve ecosystem health.

Objective g. Incorporate feedback from military trainers on quality of mission lands to assist in determining land conservation, maintenance, and rehabilitation needs and priorities.

Objective h. Suppress wildfires when necessary to protect mission land assets.

GOAL 2. MANAGE NATURAL RESOURCES, TO THE EXTENT FEASIBLE, WITHIN THE CONTEXTS OF WATERSHEDS, ECOLOGICAL GROUPS, AND LAND-USE / -CONDITION MATRICES.

Objective a. Delineate, at the scales necessary to meet different management needs, those watersheds that encompass at least a portion of Fort Benning and, when appropriate, adjacent areas outside the installation's boundary.

Objective b. Determine stream order for Fort Benning's aquatic ecosystems.

Objective c. Use watershed boundaries and stream order, as appropriate, as a framework for monitoring strategies, watershed restoration projects, and other management actions.

Objective d. Coordinate the use of watershed boundaries for management actions, such as timber harvest and the application of prescribed burns, with the use of military compartment designations to reduce conflicts, maintain a safe training environment, and enhance ecosystem-based natural resource management approaches.

Objective e. Delineate the vegetation types that occur across the Fort Benning landscape and aggregate these into ecological groups according to association with similar environmental settings and ecological processes. Use these ecological groups to devise management guidelines appropriate to each group.

Objective f. Use land-use versus ecological condition matrices to determine the appropriate management objective (that is, ecological integrity versus ecosystem health) and strategy (that is, ecological restoration versus ecological rehabilitation) to reach the objective for each land-use area.

GOAL 3. RESTORE AND MAINTAIN A VARIETY OF ECOSYSTEMS, WITH AN EMPHASIS ON THE LONGLEAF PINE (PINUS PALUSTRIS) ECOSYSTEM, TO CONSERVE NATIVE BIOLOGICAL DIVERSITY AND THE ECOLOGICAL PROCESSES THAT SUSTAIN IT.

Objective a. Establish an installation-wide vision of how the Fort Benning landscape should appear and function as a sustainable, natural (to the extent achievable), managed forest within a military training environment. This vision should account for appropriate restoration of the longleaf pine ecosystem, including necessary conversion from other forest vegetation types, and also address the maintenance of a diversity of forest / woodland alliance vegetation types appropriate to the physiognomic, soil, hydrologic, and microclimatic diversity present at Fort Benning.

Objective b. Restore and maintain ecosystems consistent with the maintenance of red-cockaded woodpecker (Picoides borealis) nesting (cluster locations) and foraging habitat, as well as future replacement stands needed for the foregoing.

Objective c. Use information on the historic vegetation and land use of Fort Benning, as well as current soil type information, to assist in developing restoration plans.

Objective d. Determine the present ecological condition of the installation's ecosystems to assist in developing restoration plans and setting priorities.

Objective e. Restore longleaf pine where it is ecologically appropriate using both natural and artificial means.

Objective f. Restore, by reintroduction and / or by the use of prescribed fire, those pyrophytic grasses and other native plants characteristic of the understory of the longleaf pine ecosystem.

Objective g. Use fire to restore and maintain the longleaf pine ecosystem, as well as those ecotonal communities that depend in part on fire to maintain their biological diversity.

GOAL 4. MANAGE HARDWOODS USING AN ECOSYSTEM APPROACH: CONSERVE HARDWOODS WHERE THEY ARE ECOLOGICALLY APPROPRIATE AND CONTRIBUTE TO OVERALL BIOLOGICAL DIVERSITY; CONVERSELY, CONTROL HARDWOODS WHERE THEY ARE DETRIMENTAL TO MANAGEMENT GOALS AND OBJECTIVES, INCLUDING RESTORATION OF THE LONGLEAF PINE ECOSYSTEM.

Objective a. Determine past hardwood community occurrence and distribution from historical data and depict in a geospatial format.

Objective b. Determine present hardwood community occurrence and distribution and depict in a geospatial format on vegetation alliance and ecological group maps.

Objective c. Develop management criteria for hardwoods, with an emphasis on either conservation or control, that reflect the historical occurrence data of hardwood communities and the longleaf pine ecosystem, current condition of the physical and biological environment, and the needs of listed species and overall biological diversity.

Objective d. Conserve ecotones between pine and hardwood communities in upland, slope, and bottomland sites by using fire and other silvicultural activities as the primary management tools.

Objective e. Do not purposely burn bottomland hardwood communities. Use an adaptive management approach to introduce fire to other hardwood communities that depend on fire for their maintenance.

Objective f. Monitor the impacts of fire and other silvicultural activities on hardwood communities.

GOAL 5. MANAGE AQUATIC AND WETLAND ECOSYSTEMS TO RESTORE AND MAINTAIN THEIR ECOLOGICAL INTEGRITY.

Objective a. Delineate stream- and upland-associated wetlands in a geospatial format by incorporating, and updating as necessary, information from the U.S. Fish and Wildlife Service's National Wetlands Inventory.

Objective b. Develop management strategies to restore and maintain the ecological integrity of Fort Benning's aquatic and wetland ecosystems.

Objective c. Use applicable Best Management Practices during timber harvests, habitat manipulations for wildlife, and military training activities to prevent degradation of wetland hydrological and biological functions.

Objective d. Use silviculture and fire to restore and / or maintain natural ecotones between wetlands and uplands.

Objective e. Mitigate any unavoidable impacts to wetlands resulting from installation activities. Restore degraded aquatic and wetland ecosystems when opportunities and resources permit.

Objective f. Evaluate the feasibility and cost-effectiveness of establishing a wetlands mitigation bank to compensate for the loss of wetlands due to training activities or projects.

Objective g. Monitor aquatic and wetland ecosystems on a watershed basis for water quality, hydrologic function, and biotic integrity.

Objective h. Initiate an educational program to increase military and civilian awareness of the importance of aquatic and wetland systems to the installation's ecological integrity.

GOAL 6. DEVELOP A STRATEGY FOR MANAGEMENT OF DESIGNATED UNIQUE ECOLOGICAL AREAS.

Objective a. Characterize the physical and biological features of currently identified Unique Ecological Areas, characterize new areas as they become identified, establish appropriate boundaries (including buffer zones) for each area, and delineate the boundaries of each area in a geospatial format.

Objective b. Develop for each Unique Ecological Area a set of management guidelines to include the types of military training that can take place without adversely impacting the ecological integrity of each area.

Objective c. Initiate an educational program to increase military and civilian awareness and acceptance of Unique Ecological Areas.

Objective d. Develop and implement a monitoring strategy for Unique Ecological Areas. Review the status and condition of Unique Ecological Areas annually with an interdisciplinary team and take the necessary management actions to maintain these areas.

Objective e. Identify those Unique Ecological Areas, or portions thereof, that require little or no active management to maintain their condition and, as a result, can serve as reference sites for the biodiversity and ecological processes associated with natural communities.

GOAL 7. USE FOREST MANAGEMENT AS PART OF AN ADAPTIVE MANAGEMENT APPROACH THAT FOCUSES ON THE ECOLOGICAL INTEGRITY OF THE LANDSCAPE AS ITS PRIMARY END STATE.

Objective a. Use modeling to help predict future stand composition, structure, and age under different harvesting and reforestation scenarios. Use the preceding model to assist in planning longleaf pine restoration and to ensure future stand conditions favor the continued viability of red-cockaded woodpeckers at Fort Benning.

Objective b. Use an uneven-aged management approach for pine and mixed pine / hardwood stands.

Objective c. Use silviculture, including the use of fire, such that their primary emphases are to maintain a realistic training environment and to support the habitat needs of listed and other species of conservation concern.

Objective d. Use thinning, single-tree selection, and small group cuts as the primary silvicultural prescriptions.

Objective e. Structure timber harvest contracts to favor harvest methods that best protect the ecological integrity of a stand offered for sale and to ensure that Best Management Practices are used. Monitor contract implementation to ensure compliance with sale conditions.

Objective f. Collect forest inventory, including post-harvest, data that facilitates tracking the status of longleaf pine restoration.

Objective g. Adjust methods of site preparation to account for the presence of desirable native species that may be sensitive to ground disturbance or the presence of residual pesticides.

Objective h. Optimize the use of appropriate seed and seedling stock and planting techniques to best ensure the viability of longleaf pine seedlings and eventual natural stand structure of the plantings.

Objective i. Use prescribed fire at the frequencies, timing, and intensities appropriate to restore and maintain longleaf pine communities, to enhance overall plant community diversity, and to support habitat management needs of the red-cockaded woodpecker.

Objective j. Prioritize prescribed burns on an annual basis such that, to the extent achievable within a military training environment, the priority best reflects the goals of longleaf pine ecosystem restoration and listed species recovery or maintenance.

Objective k. Use existing natural and previously constructed, human-made firebreaks as much as possible; if new firebreaks are needed, avoid placing them in ecotones. Let fire determine the characteristics of ecotones, except when detrimental to listed plant species or native plant communities.

Objective l. Monitor the effects of prescribed burning on hardwood control, longleaf pine regeneration, rare plants, and native herbaceous species recovery.

Objective m. Develop a strategy for the management of wildfires that defines what fires are suppressed and what fires are allowed to burn.

Objective n. Initiate an educational program to increase the public's awareness of the benefits of prescribed fire and sound silvicultural practices.

GOAL 8. PROVIDE MULTIPLE-USE OPPORTUNITIES THAT INCLUDE A SUSTAINED YIELD OF QUALITY FOREST PRODUCTS.

Objective a. Manage the Timber Program in a manner that makes it self-supporting over the long-term by providing opportunities for producing quality commercial wood-fiber products, such as lumber, pulp, pole, and plywood, to achieve a reasonable economic return.

Objective b. Manage the Timber Program in a manner that prioritizes the ecological integrity of the landscape and a realistic military training environment before maximum economic return.

Objective c. Consider providing secondary forest products, such as pine straw, longleaf pine seed, firewood, and resinous wood, when their methods of harvest are compatible with or even support other management goals and objectives.

Objective d. Consider managing for commercial hay production, where feasible, those permanent openings that are normally maintained for military training purposes by mowing (for example, Lawson Army Air Field and drop zones).

Objective e. Use training areas that are maintained in an open but grass-vegetated state as areas amenable to temporary wildlife food plantings, when appropriate and to the extent that the primary use is not adversely impacted.

Objective f. Incorporate multiple-use planning in the installation's timber management plan and in all timber harvest prescriptions to include non-timber considerations, such as: military training, outdoor recreation, soil and water conservation, listed species and wildlife habitat maintenance and enhancement, aesthetics, cultural resource protection, and forest stand development.

Objective g. Seek opportunities for achieving dual use of the land; for example, plant wildlife food / cover species within powerline rights-of-way, conduct bulldozer training in borrow pits, and conduct low impact military training in wildlife openings.

Objective h. Provide for bird watching opportunities by managing to promote the occurrence of a variety of neotropical migrants and other birds. Develop trails and observation platforms when appropriate.

Objective i. Encourage, to the extent compatible with safety and the military training mission, research on the installation's natural resources. Link research projects with opportunities to provide public education.

Objective j. Provide for, to the extent compatible with safety and the military training mission, recreational / educational opportunities, such as river / stream float trips, hunting / fishing opportunities, and forest walks.

Objective k. Expand the use of volunteers to meet natural resource management needs in accordance with Fort Benning's Volunteer Program guidelines.

GOAL 9. DEVELOP A COMPREHENSIVE STRATEGY FOR LAND CONSERVATION, MAINTENANCE, AND REHABILITATION.

Objective a. Require the use of all applicable Best Management Practices for all soil disturbing activities that may occur during construction, maintenance, and rehabilitation projects, forest management activities, and wildlife habitat improvement projects. Ensure all appropriate contracts include the use of applicable Best Management Practices as a requirement.

Objective b. Develop and implement management plans that address soil conservation and mission land sustainability.

Objective c. Ensure for applicable projects that an approved soil conservation plan is implemented before any project activity commences that may cause soil erosion.

Objective d. Develop and implement a management strategy for locating, operating, and closing borrow areas that minimizes adverse impacts to the environment and leads to eventual restoration or rehabilitation, as appropriate, of closed borrow areas.

Objective e. Close roads to vehicular travel that are not in use, or where alternate routes are available, and whose closure would contribute toward reducing soil erosion. Develop an installation-wide road closure plan to identify roads that should be closed.

Objective f. Use a watershed context to monitor for changes in the condition of soil and water resources and to assist in determining and prioritizing maintenance and rehabilitation projects that address soil erosion.

GOAL 10. MANAGE SPECIES OF CONSERVATION CONCERN USING AN ECOSYSTEM APPROACH TO MAINTAIN THE ECOLOGICAL INTEGRITY OF THE LANDSCAPE WHILE STILL CONTRIBUTING TO SPECIES RECOVERY OR MAINTENANCE.

Objective a. Seek opportunities to manage for multiple species or communities while meeting the management needs of species of conservation concern.

Objective b. Assess management actions for possible adverse impacts to non-target species and communities, when managing for the needs of species of conservation concern. Attempt to avoid or minimize such impacts.

Objective c. Ensure, for all projects and military training activities that could potentially impact listed species, that the project or activity area has an up-to-date inventory for each listed species that may be present and impacts to listed species are assessed, and mitigated if necessary, in accordance with the requirements specified by appropriate National Environmental Policy Act (NEPA) documentation.

Objective d. Identify habitat requirements for all federally listed species and other appropriate species of conservation concern. Develop an ecosystem-based strategy to maintain, protect, and enhance these habitats.

Objective e. Develop and implement management plans for all federally listed species and other selected species of conservation concern.

Objective f. Manage for red-cockaded woodpeckers by: meeting the requirements of the Reasonable and Prudent Alternatives from the September 22, 1994 Biological Opinion of the U.S. Fish and Wildlife Service, following the 1996 "Management Guidelines for the Red-cockaded Woodpecker on Army Installations," and continuing to recover the population toward the Regional Recovery Goal.

Objective g. Identify, as appropriate, target population goals for listed species and selected species of conservation concern.

Objective h. Conduct long-term monitoring of the population and habitat status of federally listed species and selected species of conservation concern.

Objective i. Coordinate inventory, monitoring, management, and research efforts, and share data resulting from such efforts, with appropriate federal and state natural resource agencies and state Natural Heritage Programs.

GOAL 11. MANAGE GAME SPECIES, INCLUDING SPORT FISH, AND NONGAME SPECIES USING AN ECOSYSTEM APPROACH.

Objective a. Develop and implement a game management plan that determines an appropriate scale of program implementation, such that recreational opportunities are provided, but the training mission, listed species recovery, and ecological integrity of the landscape are not adversely impacted.

Objective b. Modify traditional game management practices, to the extent practical, to be compatible with an ecosystem-based approach.

Objective c. Identify habitat requirements for selected game and nongame species. Develop an ecosystem-based strategy to maintain, protect, and enhance these habitats.

Objective d. Develop and implement management plans to achieve population objectives for selected game and nongame species.

Objective e. Manage to conserve those birds for which protection is identified under the Migratory Bird Treaty Act.

Objective f. Monitor the population status and habitat needs of game and nongame species by selecting those species that are sensitive to management actions and / or that can act as indicators of ecological change.

Objective g. Coordinate inventory, monitoring, management, and research efforts and share data resulting from such efforts with appropriate federal and state natural resource agencies and state Natural Heritage Programs.

GOAL 12. MANAGE PROBLEMATIC SPECIES TO ELIMINATE OR MINIMIZE ADVERSE IMPACTS TO NATURAL RESOURCES.

Objective a. Continue to implement a comprehensive and integrated pest management program that conforms to the policy, procedures, and requirements specified in the Department of Defense Instruction on pest management programs; annually review the program strategy and revise as necessary.

Objective b. Emphasize the use of Integrated Pest Management (IPM) techniques as a means to reduce pesticide risk and prevent pollution.

Objective c. Ensure that the technical portions of contracts involving pest management reflect the methodology of Integrated Pest Management.

Objective d. Develop and implement a management strategy that attempts to eradicate, or contain to the extent attainable, kudzu (*Pueraria lobata*).

Objective e. Develop and implement a management strategy to contain, to the extent attainable, other undesirable plants with an emphasis on those undesirable plant species that potentially impact listed species, undermine ecological integrity, or degrade military training activities.

Objective f. Develop and implement a management strategy for the aggressive containment of insects and disease organisms that adversely impact the timber resources of the installation, while accounting for the potentially adverse ecological impacts caused by specific containment methods.

Objective g. Develop and implement a management strategy that attempts to eradicate, or contain to the extent attainable, feral swine (*Sus scrofa*).

Objective h. Develop and implement a management strategy to contain, to the extent attainable on mission lands, other nuisance animals with an emphasis on those non-native nuisance animal species that potentially impact listed species, undermine ecological integrity, or degrade military training activities.

Objective i. Monitor the status of undesirable plant and nuisance animal species and their impacts to natural resources.

Objective j. Continue to conduct Integrated Pest Management activities for nuisance animals in the cantonment areas to promote safety, human health, and an acceptable quality-of-life.

Objective k. Establish a list of plant species to be used for site restoration projects, with an emphasis on native species; establish a list of plant species that should not be introduced in any capacity on the entire installation.

Objective l. Do not permit the purposeful introduction of non-native animal species with the exception of those animal species approved for use as biocontrol agents by appropriate Federal and / or state authorities.

GOAL 13. MEET PLANNING LEVEL SURVEY REQUIREMENTS AND NATURAL RESOURCE MANAGEMENT DATA NEEDS BY CONTINUING TO INVENTORY THE NATURAL RESOURCES OF FORT BENNING.

Objective a. Complete Planning Level Survey requirements.

Objective b. Develop an accurate vegetation alliance map of the installation.

Objective c. Characterize the understory of the installation's longleaf pine ecosystem and other plant community types of management concern.

Objective d. Complete a 100 % inventory of federally listed and candidate species, state-listed species, and other appropriate species of conservation concern every 10 years or sooner if required by specific management plans.

Objective e. Update forest inventory data on a periodic basis, not to exceed every 10 years.

GOAL 14. DEVELOP AND IMPLEMENT A COMPREHENSIVE, ECOSYSTEM-BASED MONITORING STRATEGY THAT TRACKS INDICATORS OF ECOLOGICAL CHANGE, ENABLES THE DETERMINATION AND USE OF ECOLOGICAL THRESHOLDS, FACILITATES ADAPTIVE MANAGEMENT, AND LEADS TO A SUSTAINABLE TRAINING ENVIRONMENT BY PROVIDING A BASIS FOR EFFECTIVE LAND-MANAGEMENT DECISIONS.

Objective a. Conduct baseline monitoring of the installation's physical, chemical, and biological environment via the Ecosystem Characterization and Monitoring Initiative (ECMI) to support: Department of Defense, Strategic Environmental Research and Development Program's (SERDP) ecosystem science research objectives, regional ecosystem management initiatives, and installation-specific ecosystem management initiatives.

Objective b. Continue to conduct monitoring via the Land Condition Trend Analysis (LCTA) component of the Integrated Training Area Management (ITAM) Program. Add new monitoring plots, as necessary, to enable monitoring within a watershed context to facilitate land-use decisions and other management actions.

Objective c. Integrate and supplement monitoring accomplished under the Land Condition Trend Analysis component with other program monitoring needs.

Objective d. Determine those environmental metrics that best meet the management goals for monitoring over the long-term, based on the results of the Ecosystem Characterization and Monitoring Initiative, Strategic Environmental Research and Development Program research, and other available data.

Objective e. Ensure all monitoring data collected are appropriate to the management objectives they are designed to support and are repeatable, statistically analyzable, and scientifically rigorous.

GOAL 15. CONTINUE TO DEVELOP AND MAINTAIN A THOROUGH DATA COLLECTION AND PROCESSING SYSTEM THAT PROVIDES EFFICIENT DATA STORAGE, RETRIEVAL, SHARING, ANALYSIS, AND PRESENTATION TO SUPPORT MONITORING REQUIREMENTS AND TO FACILITATE FULLY INFORMED MANAGEMENT DECISIONS.

Objective a. Maintain data storage, to include geospatial data layers, in a format that is compatible with the needs of all appropriate users on the installation.

Objective b. Identify which programs will have the installation-wide responsibility for maintaining, updating, and making available to other users specific kinds of natural and cultural resource data.

Objective c. Maintain a geospatial data base consisting of all known occurrences of listed species and other selected species of conservation concern, Unique Ecological Areas, and plant associations of conservation concern.

Objective d. Ensure that all appropriate data are accessible to onsite users and the public.

Objective e. Ensure that sensitive natural and cultural resource data are safeguarded and released only to those individuals / organizations that are entitled to the data in the course of their work.

Objective f. Continue to develop a list of available data bases.

GOAL 16. COORDINATE THE ACTIONS OF APPLICABLE INSTALLATION DIRECTORATES TO FACILITATE THE RECOGNITION AND INCORPORATION OF NATURAL AND CULTURAL RESOURCE CONSIDERATIONS INTO LAND-USE PLANNING, ENVIRONMENTAL REVIEW, AND WATERSHED RESTORATION PROJECTS.

Objective a. Establish command-level awareness of land use, environmental, and land maintenance and rehabilitation issues affecting mission lands. Moreover, maintain the command's awareness of its stewardship responsibilities to ensure adequate human, equipment, and financial resources are made available to accomplish management goals and objectives.

Objective b. Ensure that those organizations responsible for long range land-use planning proactively use, and appropriately incorporate into the planning process, the most currently available natural and cultural resource data to reduce potential conflicts between projected land use and resource management requirements as early in the planning process as possible; conversely, ensure natural resource managers account for land-use planning information as part of their management decision process.

Objective c. Continue to use, and improve as necessary, an environmental review process that: incorporates National Environmental Policy Act requirements, begins early in the life-cycle of a project, provides specific guidance and indicates specific requirements that a project needs to address to avoid or

minimize environmental impacts and to achieve regulatory compliance, identifies the specific time period and project conditions for which the review applies, assesses cumulative impacts, ensures project activities do not commence until appropriate approvals are in place, monitors the conduct of a project until its completion, and tracks the completion of required mitigation.

Objective d. Develop criteria for setting priorities for conducting watershed restoration projects that balance a particular watershed's vulnerability to erosion and the impact in that watershed that erosion has on natural resources, regulatory compliance, and military training activities. Prioritize those projects whose accomplishment mutually benefits resources, compliance, and training.

Objective e. Seek opportunities in which human, equipment, and financial resources can be shared between installation directorates to accomplish land maintenance and rehabilitation projects that are of mutual benefit to both sustainable, realistic military training and natural resource stewardship.

Objective f. Use coordinating councils and other management tools to: reduce conflicts, prevent duplication or contrary efforts, maximize the efficient use of available resources, and seek mutually beneficial actions.

GOAL 17. DEVELOP AND IMPLEMENT ENVIRONMENTAL AWARENESS AND ENFORCEMENT PROGRAMS THAT FOSTER THE INSTALLATION'S STEWARDSHIP OF NATURAL RESOURCES.

Objective a. Update the installation's Environmental Awareness Program to improve the level of awareness among military (resident, tenant, and visiting) and civilian personnel in regard to the importance of ecosystem integrity to military training and the steps necessary for compliance with the Endangered Species Act.

Objective b. Incorporate into environmental awareness instructional materials those educational elements needed to facilitate the installation's compliance with the U.S. Fish and Wildlife Service's 1994 Biological Opinion as it relates to a determination of a jeopardy status for the red-cockaded woodpecker.

Objective c. Develop and implement an installation environmental enforcement program that holds responsible individuals / units accountable for unauthorized and reasonably avoidable actions resulting in adverse impacts to natural resources.

Objective d. Update the installation Range and Terrain Regulation (U.S. Army Infantry Center Regulation 210-4) to reflect changes in natural resource management requirements embodied in this document and to improve the effectiveness of its environmental compliance provisions. As applicable, include provisions for specifying appropriate administrative penalties.

Objective e. Continue to enforce the installation's hunting and fishing regulation (U.S. Army Infantry Center Regulation 210-2).

GOAL 18. PROVIDE NATURAL RESOURCE-DEPENDENT RECREATIONAL OPPORTUNITIES CONSISTENT WITH SAFETY REQUIREMENTS, THE MILITARY MISSION, LISTED SPECIES REQUIREMENTS, AND THE MAINTENANCE OF ECOLOGICAL INTEGRITY.

Objective a. Determine natural resource-dependent recreational needs based on periodic surveys of user groups.

Objective b. Develop and implement an outdoor recreation management plan.

Objective c. Evaluate additional user-group recreational opportunities and expand the program if appropriate and feasible.

Objective d. Upgrade existing recreational areas and facilities when manpower, equipment, and funding resources permit. Develop new recreational areas and facilities to meet user needs when existing areas and facilities cannot be economically upgraded, or do not exist, and when manpower, equipment, and funding resources permit.

Objective e. Conduct natural resource management activities as needed to support those natural resource-dependent recreational opportunities that are compatible with safety requirements, the military mission, listed species requirements, and the maintenance of ecological integrity.

Objective f. Develop and implement educational programs to increase public environmental awareness and acceptance of installation natural resource programs.

Objective g. Evaluate the extent to which volunteers can be used to establish and maintain recreational opportunities.

GOAL 19. COMPLY WITH ALL APPLICABLE FEDERAL AND STATE ENVIRONMENTAL LAWS AND REGULATIONS RELEVANT TO NATURAL RESOURCE MANAGEMENT CONCERNS, AS WELL AS APPLICABLE EXECUTIVE ORDERS.

Objective a. Ensure that all military personnel and civilians are aware, to the extent applicable to their job and their recreational pursuits on the installation, of all applicable environmental laws and regulations.

Objective b. Track the installation's compliance with applicable laws and regulations. Take corrective action in a timely manner for conditions that place the installation out of regulatory compliance.

Objective c. Accommodate the intent of those state laws and regulations and local county and city ordinances that address natural resources, but for which the installation has no legal obligation to meet.

GOAL 20. PROTECT AND PRESERVE CULTURAL RESOURCES ACCORDING TO FEDERAL AND STATE LAWS AND REGULATIONS.

Objective a. Identify and evaluate all cultural resources present on the installation.

Objective b. Ensure that natural resource management activities do not adversely impact cultural resources. Identify potential impacts and avoidance measures in all natural resource management plans.

Objective c. Maintain a geospatial data base on all known archaeological and historical sites. Ensure appropriate sites are identified clearly on-the-ground.

Objective d. Comply with all appropriate federal and state laws and regulations applicable to cultural resources and their protection.

Objective e. Consult with relevant Native American tribes and other interested parties on projects that may affect sacred sites, traditional cultural properties, or human burials.

Objective f. Develop and implement an integrated cultural resources management plan.

GOAL 21. FOSTER EXTERNAL PARTNERSHIPS TO ENHANCE DATA SHARING, REGIONAL CONSERVATION STRATEGIES, AND MONITORING ACTIVITIES.

Objective a. Seek opportunities to work with the U.S. Fish and Wildlife Service and other conservation partners to develop and implement a regional strategy for recovering the red-cockaded woodpecker population by promoting reintroduction of the species on lands near the installation (that is, on lands that could support birds and contribute to the Regional Recovery Goal).

Objective b. Seek opportunities to work with the U.S. Fish and Wildlife Service and other conservation partners, such as Partners in Flight, to develop habitat for other species of conservation concern, to implement measures to otherwise conserve these species, and to develop cooperative agreements to facilitate management strategies.

Objective c. Develop a working relationship with the Alabama and Georgia Natural Heritage Programs to facilitate data sharing and other undertakings of mutual benefit.

Objective d. Coordinate with the Alabama and Georgia natural resource agencies and the U.S. Fish and Wildlife Service on natural resource management issues of mutual interest.

Objective e. Share appropriate natural resource data and lessons learned with other Army installations, other Department of Defense installations, and federal and state agencies. Contribute natural resource data to regional monitoring programs.

Objective f. Establish an installation Steering Committee that has oversight responsibility for the proper implementation of the provisions contained in this plan and as a result can act to resolve conflicts, coordinate implementation of plan provisions, make appropriate interpretations of policy and management direction when needed, and identify the need for plan updates. Include at least one representative on this committee that can represent natural resource conservation interests and is not a military or civilian employee of the Department of Defense. Convene meetings of this committee at least quarterly and more often if needed.

Objective g. Partner with research centers and academic institutions to encourage research on the installation's natural resources.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Department of Defense (DOD) policy has established ecosystem management as its approach to management of military lands. The DOD goal for adopting an ecosystem approach to land management is to maintain and improve the sustainability of military lands while supporting the DOD mission. The Strategic Environmental Research and Development Program (SERDP) has developed the Ecosystem Characterization and Monitoring Initiative (ECMI) to support this goal via the design, development, and demonstration of the characterization and monitoring concept for military installations. The ECMI products must support multiple research goals and be beneficial to installation land managers. The objective of ECMI was to develop a framework to characterize the long-term spatial and temporal dynamics of key ecosystem properties and processes in a way that is jointly beneficial to research needs and military land management operations. The ECMI is currently providing baseline ecological information to support (1) ecological research on Fort Benning, GA, (2) baseline level data to Fort Benning's integrated monitoring plan, (3) a long-term ecological data set that over time will allow the assessment of the relationships between land use, land management, and ecosystem sustainability, and (4) monitoring data sets collected by other agencies in the region.

15. SUBJECT TERMS

Ecological monitoring	Land management	Processes
Installations	Natural resources	Properties

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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